THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. I.—*On Perfect Harmony in Music, the Double Diatonic Scale, and an Enharmonic Key-Board for Organs, Piano-fortes, etc.;* by HENRY WARD POOLE, of South Danvers, Mass.

1. SEVENTEEN years ago I published in this Journal* a theory of Perfect Intonation in music, with a description of an organ made to obtain this result, which had then just been completed. The organ was provided with pedals and mechanism by which the large number of pipes necessary for perfect tuning could be played by the common key-board. It was supposed that all music, for the moment, was in some key or scale. This scale the organist could prepare by putting down a single pedal, which had the effect of uniting the twelve finger-keys of each octave with twelve valves, and disconnecting all the others. As the music passed into other scales, by modulation, and other less marked transitions, the player, by touching the pedal of the new scale, made the changes of sounds required. In the present paper, I shall describe a new key-board in which all the sounds contained in the organ are represented, and placed within control of the organist, without aid from pedals or any interior mechanism; and which is practicable for any extent of modulation, or number of notes in the octave. It is uniform in all keys, and the same succession of melodies or harmonies is fingered the same in every signature. The pedal-base is also provided for by an appropriate key-board. I shall also treat of the scale heretofore unnoticed by theorists, to which I have given the name of *Double Diatonic*,† together with other matters bearing upon the theory and practice of perfect harmony.

* Vol. ix, Jan., Mar., 1850. † See the Mathematical Monthly, ii, 16, 1859.

2. In my former article in this Journal it was maintained that the Prime Seventh with the ratio 4 : 7 was harmonious, admissible and used in music, although this, so far as I have seen, was asserted for the first time.* It is clearly evident that this element enters into music of all kinds, and that the diatonic scale must contain it, or that there must be *two* diatonic scales: which latter supposition is most correct. If only fifths and thirds are admitted in forming a diatonic scale it will naturally be made of the common chords of three roots, namely, the tonic or key-note, the dominant or fifth above, and the subdominant or fifth below. This I have distinguished as the *triple diatonic scale*, which has three intervals in the ratio of 8 : 9, 9 : 10, and 15 : 16. The notes are represented by the syllables Do, Re, Mi, etc., which always bear the same relation to the key-note and to each other. Thus, Do to Re is always as 8 : 9 or a major tone, Re to Mi as 9 : 10 or a minor tone, Mi to Fa as 15 : 16 or a diatonic semitone. No exception is admitted in this rule. Considering the key-note to make 48 vibrations in a given time, we have the

TRIPLE DIATONIC SCALE. Do to Do.

Common chords on Do, Sol *and* Fa.

	Do	Re	Mi	Fa	Sol	La	Si	Do
Rel. vibrations,	48	54	60	64	72	80	90	96
	First.	Second.	Third.	Fourth.	Fifth.	Sixth	Seventh.	Octave.
Intervals,	8 : 9	9 : 10	15 : 16	8 : 9	9 : 10	8 : 9	15 : 16	

3. But if the ear prefers—and it often does prefer—the subdominant harmony may be suppressed, and the fourth of the scale, Fa, and the sixth, La, may be replaced by the perfect seventh and ninth of the dominant harmony; so that if we still take *Do* as a starting point or first of the scale, we require a *new Fa* and *La*, for which formerly there have been no names. But the perfect seventh, or *flat seventh* as it is called, is already in solmization sung as *Si*^{b}, taking the sound of *Se*—pronounced by the Italian rules as are all these syllables, and like the English *Say*—and no other name is needed. Below *Si* therefore we take *Se*, and take as first of a scale the *Fa* already given. Then we have the

DOUBLE DIATONIC SCALE. FA to FA.

Common chord on Fa, *chord of* 7 *and* 9 *on* Do.

	Fa	Sol	La	Se	Do	Re	Mi	Fa
Rel. vibrations,	32	36	40	42	48	54	60	64
or	48	54	60	63	72	81	90	96
	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Octave.
Intervals,	8 : 9	9 : 10	20 : 21	7 : 8	8 : 9	9 : 10	15 : 16	

* The German "Jahrbuch" of Liebig and Kopp, in a discriminating review of my article in this Journal in 1850, specified this declaration.

4. The reasons for taking the key-note on *Fa* will appear on consideration, but for the present the reader will recollect that if the flat seventh of the natural key is taken—for example B^b with the common chord of C—the ear requires a resolution on the chord of F or *Fa*, which is the controlling note.

5. To sing this scale is easy, provided the intervals of the triple scale are well fixed by their syllables; and it only remains to learn the intervals *La* to *Se*, 20 : 21, and *Se* to *Do*, 7 : 8, which are easily recognized on hearing the harmony which should accompany a lesson in singing. In the last scale are five different intervals in place of the three of the first scale, by which more variety is secured.

6. These two scales contain all that belongs to the major keys; the additional notes required to complete the minor keys will be considered afterwards, as well as those called "accidentals," which are borrowed from related scales. The notation generally employed in music is practically correct, and, without changing the letters or sharps and flats, scales may be noted so that the exact sounds shall be indicated. In all times a singer must know or *feel* the pitch of each note, if he would sing it correctly. If he has learned the intervals by solmization, in the only rational way, or by always giving the same intervals to the same succession of syllables, and if he knows by the written music what intervals are called for, he will give them equally well in the key of C or in $C\sharp$, or on the dozen different pitches which can be given between these two sounds. But when we are to deal with fixed sounds, as is necessary when constructing an instrument, or when two fixed instruments may have to play together, it is necessary to know and express the exact sounds required. If the note be C, it will not do to use that which is the key-note of the natural scale for the third of four flats, which is a comma lower, nor for the perfect seventh of D, two sharps, which is lower still. I formerly indicated this distinction by a numerical index, but the following system presents advantages.

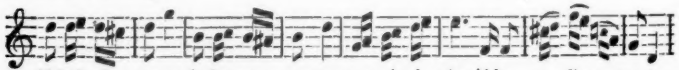
7. Every key-note is marked as usual, but with a Roman capital; every major third to these key-notes with Roman lower case, and every perfect seventh with a Gothic capital. The second, fourth and fifth of the triple diatonic scale, being key-notes in other scales, and in the series of key-notes, each a fifth one from another, are accordingly in Roman capitals. So the sixth and seventh of the same scale are thirds of other keys, and marked in letters of the lower case. The two diatonic scales will then be represented thus in the natural key.

Triple diatonic,	C	D	e	F	G	a	b	C
	Do	Re	mi	Fa	Sol	la	si	Do
Double diatonic,	C	D	e	**F**	G	A	b	C
	Fa	Sol	la	**se**	Do	Re	mi	Fa

8. Much that is curious and interesting concerning this double diatonic scale could be shown, did the character of this article admit, and were it practicable to give musical examples from the masters. It would be seen that the most beautiful, varied and ornate compositions are made from the elements it contains. It has the capacity in certain styles of music of using with much grace accidentals, or chromatics, as they are called; for example, the *si*, the regular leading note to *Do*, and the *Sol*♯, diatonic semitone below *la*, or the leading note to the relative minor; these chromatics always ascending diatonic semitone (15 : 16) to the notes above. Especially is the *si*, or major seventh, used with *Do*, making the ratio of 8 : 15, if it is to be considered as claiming to be attended to as concordant, or as otherwise than as a passing note of a melody. But when perfectly tuned it is heard in harmony, especially with the *mi* and *Sol* with which it is sounded. An example will be given to illustrate this. First, it may be mentioned that besides the three series of notes—key-notes, thirds and sevenths—another series is used, that of the dominant's thirds in the minor scales, the leading notes to the relative minor's key-note. This in each key is *Sol*♯, and is tuned a major third above *mi;* and *mi*, *Sol*♯ and *si* form a major common chord (4 : 5 : 6). These notes are expressed in italic letters of the lower-case. The example being the double diatonic scale of G, in one sharp, I shall give this scale with the accidentals introduced in the following melody from Rossini's 'Il Barbiere di Seviglia.' The air will be remembered as appearing in the accompaniment to the song or recitative (for it is all on one note, D or Do, the part which this accompanies), in which Figaro describes his place of business, (*Numero quindici*, etc.), and afterward is the air sung by Almaviva when he has a prospect of seeing Rosina, while at the same time Figaro sings in joy at the sound of his patron's gold.

DOUBLE DIATONIC SCALE IN G, WITH ACCIDENTALS.

G	A	*a*♯	b	**C**	*c*♯	D	E	*f*♯	G
FA	SOL (*sol*♯)	la		**Se**	(*si*)	Do	RE	*mi*	FA

Almaviva sings

Harmony of the accompaniment.

G - - - - - - - - - - - - - - - - D with the 7th - - G

9. Although it is convenient to consider a special strain of music as being in a definite key or scale, and to consider the notes which are sometimes prone to introduce themselves as "accidentals," and in a manner extraneous, yet the truth is that

all such intruders have the excuse of being relatives, with the right of entrance, under certain rules, which the great masters understand. Among the related notes in the scale in G, last given, are C and e, or the fourth and sixth of the double diatonic on the same key-note, G. These are introduced in a passing manner, as in the cadence—a familiar example is found in the *Oh! dolce concento** of Mozart—where the subdominant harmony, not before heard, comes in just before the final dominant and tonic chords. In the example given from Rossini, the third note of the third measure may be C, as well as **c**—*Fa* of the triple scale, as well as *Se* of the double. In the fifth measure the fourth note may be the same C, and the sixth note may be e, the sixth or *la* of the triple scale of G. But the following note on the same degree in the sixth measure is clearly and necessarily E, Re, or the ninth of the chord of the seventh on D. So the third note of the first measure may be e. The enharmonic change from e to E, a rise of a comma, is often required, is very beautiful, and I have proved that it can readily be made for my singers, who know this change of a comma as well as others know the tone or semitone, will give it, even without accompaniment, with perfect accuracy, as proved by the harmony afterward applied as a test. All this variety within the limits of musical laws—which only forbid what is disorderly, complicated, or what the ear will not distinguish—adds to the pleasure of music, and it is the exact rendering of all the melodies and harmonies which gives the charm to a good singer. When acutely perceptive of such accuracy, I had the good fortune to listen to Alboni on all the occasions when it was possible to do so. I thought her then, and still am of the opinion, that she was the best singer I have ever heard. It is certain that she had a wonderful exactness in executing whatever she undertook. There was no "temperament" in *her* scales, and what the strictest theory requires in intonation she understood and gave. She sang music whose analysis would alarm a student with its apparent difficulties; but the delighted auditors perceived only a delicious and "easy" flow of melody.

10. Fortunately, the greater part of the difficulties in the higher class of melodies are overcome by the unconscious or instinctive talent of the singers. The accompaniment of such melodies is not difficult, and the harmonies attending make clear what the melody must be. No instrument will ever compete with the voice in its peculiar department, but may surpass it in that which it is fitted for. Neither voices nor instruments separately can produce the highest effects in music; those will be attained by the combination of the two. Improvement in the

* Generally so called. It is the air in Mozart's *Il Flauto Magico*, "*Oh! cara armonia.*" From this is taken the song "Away with melancholy."

instruments which accompany will be followed by better vocal music.

11. For understanding what is to follow, I would have it borne in mind, that I consider that all musical ratios derived from the primes 3, 5, and 7 are appreciable by the ear, and may be used in all their combinations and transpositions into different keys, which is already done in a series of perfect fifths. The next prime, the eleventh, does not present sufficient claims to be admitted to the musical canon, except under regulations which as yet I would not undertake to define. I can tune it, and can perceive that it yields harmony so far as to give coincidences in its vibrations with the other prime chords, the fifth, the third and the seventh. It is not impossible, when a great refinement is made in music, and the sense highly cultivated, that this class of novel sounds may be introduced and appreciated. But except under such conditions, and without the most exact intonation, the eleventh would fail to give any effect other than incomprehensible discord. It might be admissible in the harmonic stops of an organ—those called mixtures, sesquialtras, etc.—but only under a system of perfect harmony.

12. For a practical instrument I would provide five series of sounds—a series signifying that each sound is a fifth from that which precedes, and that which follows it. These five series, arranged in the order of their importance, are as follows, the notes of each series being marked with the letter and sharp or flat in common use, but in a distinctive type for each series:

Series I.	Key-Notes.	Roman capitals, A, B.
" II.	Thirds (major) to key-notes, series I,	Roman lower-case, a, b.
" III.	Perfect sevenths to key-notes, " I, (These constitute the major scales.)	Gothic capitals, **A, B.**
" IV.	Dominant thirds (major), in the minor mode, being major thirds to II,	Italic lower-case, *a, b.*
" V.	Dominant sevenths, in the minor mode, being perfect sevenths to II, (These two last complete the minor mode.)	Gothic lower-case, **a, b.**

13. This being understood, it will be known that the same letter in the same type is always the same sound, and its relation evident; that the same letter in Roman lower-case is a comma lower than the same in capitals, and a quarter (0·256) of a comma higher than the seventh in Gothic capitals. A letter of the III series, in Italics, is two commas below the same in the I series, or one comma below that of the II. The sevenths of the V are one comma below those of the III; the lower-case letter indicating this difference below the capital.

14. Among the names which have to be remembered as advocates of perfect harmony and just ideas in music, perhaps the first in modern times is that of Gen. T. Perronet Thompson of

London. My first knowledge of his valuable services came during the preparation of the second part of my article in this Journal (in March, 1850), by an allusion in the Westminster Review to an enharmonic organ which he had just brought out in London. This led to the reading of his spirited articles on music and other subjects in the Westminster Review, and to the seeking his acquaintance, which, through a considerable correspondence, I have had the good fortune to make. I have also received his "*Theory and Practice of Just Intonation*" and "*Description and use of the Enharmonic Organ*" of his invention, "*built for the Exhibition of* 1851, *and an Appendix tracing the identity of design with the Enharmonic of the Ancients.* London, 1850." 8vo. I also obtained, after much search, and by the kind efforts of the author, what appears to be the initiative work of Gen. Thompson in musical doctrines. Although a work requiring thorough classical and mathematical knowledge, as well as information in several departments of literature and taste, it bears the modest title, "*Instructions to my Daughter for Playing on the Enharmonic Guitar, being an attempt to effect the execution of correct harmony, on principles analogous to those of the ancient Enharmonic. By a Member of the University of Cambridge. London*, 1829." In folio, with illustrations. This work seems to have been stimulated by a fine perception of the delicate harmonies of which the guitar strings are capable, and by falling upon the collection of the "Seven Ancient Greek authors on Music," collected and published by Meibomius, and printed on the Elzevir press in 1652, a copy of which is in the library of Harvard College. The Euclid of geometry is one of these seven, and there is an eighth author who is not reckoned an ancient, as he lived as late as A.D. 470. It is clear that there was something which these called "*enharmonic*," which is declared to be the "*most accurate.*" (Aristides Quintilianus, lib. i, p. 19, ed. Meib.) That "the name of enharmonic [or harmony] is given to the genus abounding in the smallest intervals; from the harmonizing." (Idem, i, 18.) "The enharmonic, so called from being taken in the perfect intervalling of whatever is subjected to harmony." (Id., ii, 111.) With much more to justify Gen. Thompson in adopting the title of Enharmonic: which name I also take as appropriate to a system of perfect harmony, and to the instruments which are constructed on its principles.

15. The enharmonic organ of Gen. Thompson had key-boards in which, without any change in the interior of the organ, all sounds contained therein could be given. Every sound of the organ was represented in three key-boards, except some very rarely called for, which had exchangeable pipes. The organ of Mr. Alley and myself had a key-board like that of the common organs, and the fingering was the same: all changes were made

by pedals, one for each key, which put the organ in tune for its own scales. It could be played without the player knowing what sounds he used—he only needed to keep the organ in the right key. Gen. Thompson justly remarks that his system would have merits over ours, in compelling a musician to know what he is doing. But in the dark days of enharmonic science it may be excusable not to demand too much of the organists.

16. There are great difficulties which present themselves in admitting to a key-board the multitude of sounds required if several transpositions or signatures are to be played in. If the five series of sounds already described, § 12, are carried into the keys from nine flats to nine sharps—nineteen signatures—just one hundred notes to the octave are required! But an octave is limited in width by the span of the fingers. Six and a half inches is about the convenient average measure, and this is adopted by organ and piano-forte makers. If the notes we want are divided equally into this space each will get the hundredth part of it, or sixty-five thousandths of an inch. The pins of a barrel organ might play upon them, but with human fingers it is hardly possible.

17. But there is a fortunate circumstance in the relation of the sounds which comes to our aid. All are not wanted at the same time; when we are near the key of nine sharps there is no possibility of our requiring the notes of nine flats. These we may arrange therefore at a distance front or back, and place near by the related notes which may be required in connection with those already in use.

18. At least seven finger-keys should be in convenient relation to each other, and of sufficient size and position to allow of their being touched, and for the changes of fingers necessary in running scales and taking chords in different positions. Such a key-board I have endeavored to devise, the result of which may be seen from the following description and figures.*

19. The first point I took in the resolution of the problem was, the convenience of the broad white ivory keys of the common key-board, and the elevated black keys—the white especially affording room for shifting the fingers, and the raised keys making it easy to touch a narrow key, which it would be hard to do if all were in one level. The second: that the key-notes and the thirds, being of different classes, might be assigned to these two classes of finger-keys, naturally giving to the first class the more extended keys, or the white. So the octave ought to have its seven notes. Pieces of bristol board were cut to the width of the common white keys, or nearly an inch, and in length double that of the part in front of the black keys.

* At the time of writing (April, 1867) I have made application for a patent for this key-board.

With the same material I made elevated black keys of the width and height of those of the common key-board, and of the length of 2·7 inches, which were arranged in hopes of getting at least the diatonic scales, triple and double, which could be easily managed, and in a manner uniform for all keys.

20. This provisional key-board is not figured here, but may be understood by reference to figs. 1, 2 and 3, which contain also the additional series of sounds, IV and V, § 12. In fig. 1 let the black key, d, be moved to the left until its left edge coincides with the right edge of C, its back end as now being in contact with the front end of the white key D; let e, f♯, and the two keys (**F**^{7} and another not marked but really **E**♭^{7}) marked with vertical lines indicating their color, red, be moved in the same direction and distance as d, till they are in contact, respectively, with D and E. There is no room now for *d*♯ and **d**^{7} and their two companions by f♯, but we have all the key-notes, thirds and perfect sevenths, and the advantage of greater width in the white keys, which are nearly an inch and a quarter wide (1·21 in., the black keys being 0·45). This key-board, although deficient in the minor mode, from the absence of the series IV and V, is still recommendable where economy is necessary, as all the music of the major key, including the beautiful chord of the seventh, can be played; except in cases where certain accidentals are introduced from the minor mode, as illustrated in the example from Rossini in § 8.

21. A portion of the complete enharmonic key-board is shown in perspective in fig. 1, in the natural size—the length of the keys being reduced to one-half by the perspective. The keys are of five different colors—represented here, the white and black by their natural colors, and the rest according to heraldic rules, viz., the *red* by vertical lines, the *blue* by horizontal, and the *yellow* by white stippled with black—and of as many different elevations. The following table represents this.

Series.	Color.	Elevation.	Example.
I. Key-notes,	white	0·0	C, D
II. Thirds,	black	0·4 in.	b, e
III. Sevenths,	red	0·05 "	**F**^{7}
IV. Dom. 3ds, minor,	blue	0·10 "	*d*♯
V. Dom. 7ths, minor,	yellow	0·15 "	**d**^{7}

22. These keys all have vertical rectilinear motion so that a touch on any part of their surface produces always the same effect. This is attained—in one method—by attaching each to a pair of guiding rods, passing down through a couple of horizontal tables where they are secured to a piece which communi-

cates in the usual manner with the valves or hammers. It will be understood that the mechanical construction of the instrument beyond the key-board may be the same as usual, except that its *number* of pipes or strings must be multiplied.

23. As the assemblage of all the notes may confuse the eye at first sight, I have drawn on half scale the plan of the finger-keys which in *every signature*—or commencing on any white key whatever—give the triple and double diatonic scales. The white keys are of the width of 0·993 in., the black keys having the width of 0·45.* The white keys on the common key-board are but 0·93, or the seventh of 6½ inches. The plan in fig. 2 will enable a player to judge whether the scale can be executed. It is immediately intelligible even to a child, who, having learned the order in one key, knows it in every other. The keys are considered by their relations to each other, that is, as Do, Re, etc., and (to repeat it again), Do may be taken on any white key. The fingering in the triple diatonic scale is the same as in that of the natural key, and of others, on the common key-board, and the fingers easily reach the keys and change on Fa and Do as in the latter case. In the following scales the usual signs represent the thumb and four fingers; see fig. 2.

TRIPLE DIATONIC SCALE—*Its fingering.*

Do	Re	mi	Fa	Sol	la	si	Do
+	1	2	+	1	2	3	4 (or +)

DOUBLE DIATONIC SCALE—*Its fingering.*

Fa	Sol	la	Se	Do	Re	mi	Fa
+	1	2	3	+	1	2	3

The player is recommended to complete the octave, Fa to Fa, by copying the four lower keys, Do, Re, mi, Fa, figs. 2, 3, and placing the lower Do upon the upper one, or by conceiving that this has been done. This will show the double scale in its regular order.

24. I regret that the limits of these pages did not allow a larger portion of the key-board, and permit reference to it in the manner of taking the several chords in their various positions. But I think that those interested can extend the diagrams by the data given, and I shall, therefore, give the fingering for several chords, which being understood in one key will be the same in all transpositions.

* The widths are established thus: first determine the width of the octave, and that of the black keys. Representing these respectively by O, and b, the width of the white key (W), is obtained thus: $\frac{O+b}{7}=W$. For the key-board for major keys, only, § 20, the formula is $\frac{O-b}{6}=W$.

Fig. 1.—ENHARMONIC KEY-BOARD

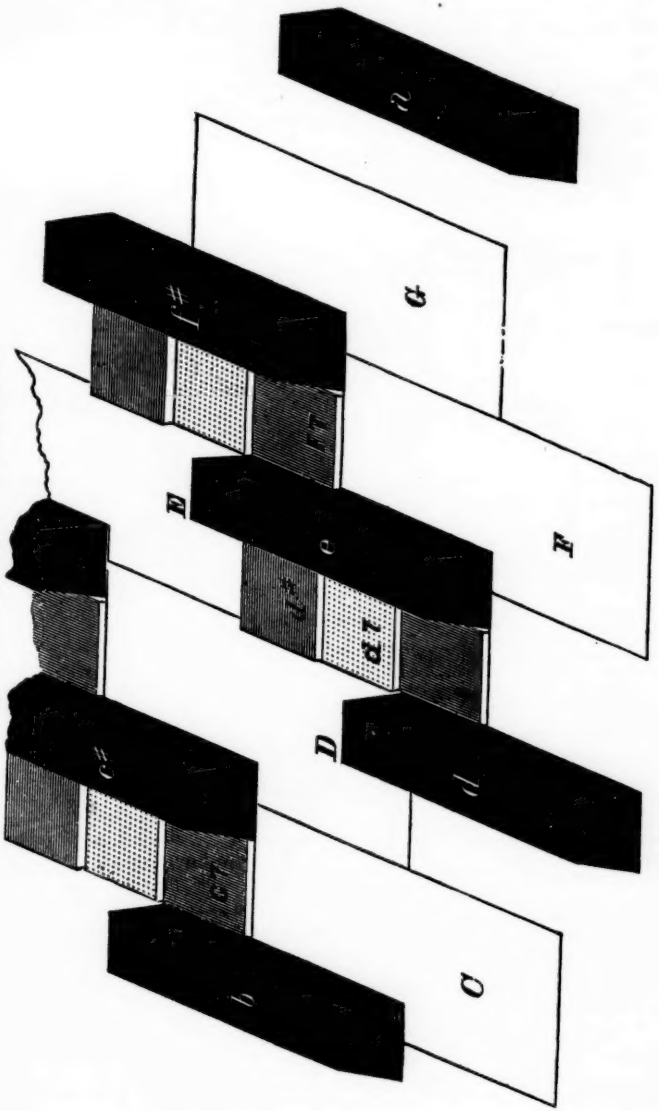


Fig. 1.—ENHARMONIC KEY-BOARD.

Fig. 2.—A portion of the Enharmonic Key-board, showing the relative position of the Finger-keys which give the Triple and Double Diatonic Scales in every key or signature, or taking Do on any white key.—*Scale of one-half.*

The white and black keys are represented in their natural colors; the red keys—perfect sevenths—by vertical lines; the blue keys—dominant thirds in the minor mode—by horizontal lines; the yellow keys—dominant sevenths in the minor mode—by white stippled with black.

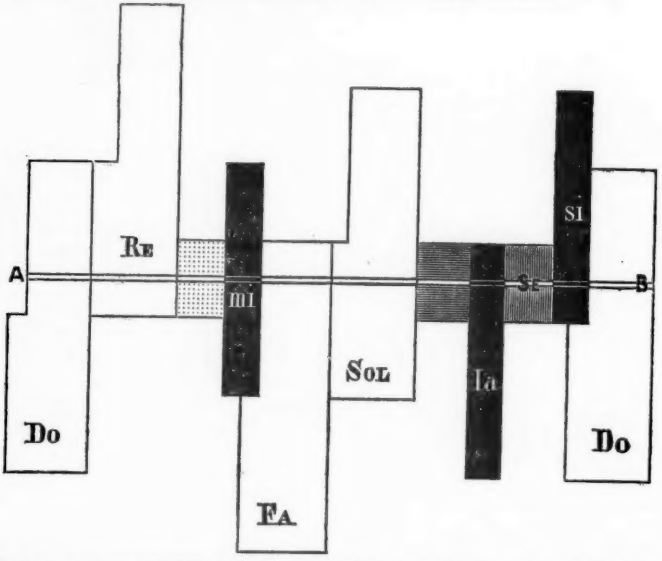
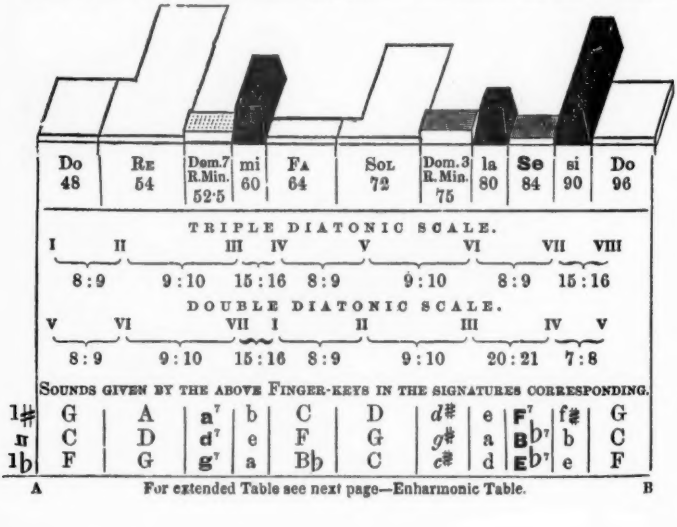


Fig. 3.—Section through A B, or through the third quarter of any key-note, exposing all the notes of that key both in the Major and Minor modes.


Do 48
Re 54
Dom.7 R.Min. 52·5
mi 60
Fa 64
Sol 72
Dom.3 R. Min. 75
la 80
Se 84
si 90
Do 96
TRIPLE DIATONIC SCALE.
I II III IV V VI VII VIII
8:9 9:10 15:16 8:9 9:10 8:9 15:16
DOUBLE DIATONIC SCALE.
V VI VII I II III IV V
8:9 9:10 15:16 8:9 9:10 20:21 7:8
Sounds given by the above Finger-keys in the signatures corresponding.
1♯ G A a⁷ b C D d♯ e F⁷ f♯ G
♮ C D d⁷ e F G g♯ a B♭⁷ b C
1♭ F G g⁷ a B♭ C c♯ d E♭⁷ e F
A
B

For extended Table see next page—Enharmonic Table.

ENHARMONIC TABLE,

COMPRISING THE NOTES GIVEN BY THE SECTION AB, FIGS. 2, 3, IN THE SIGNATURES FROM 9 FLATS TO 9 SHARPS, AND CONTAINING THEIR DIATONIC SCALES, INCLUDING THE MINOR MODE. 100 NOTES TO THE OCTAVE.*

TRIPLE DIATONIC SCALE.

Signature.	Do	Re		mi	Fa	Sol		la		si	Do
	Key-note.	Second.		3d.	Fourth	Fifth.		6th		7th.	Octave.
9♯	D♯	E♯	e♯⁷	f×	G♯	A♯	*a*×	b♯	C♯⁷	c×	D♯
8♯	G♯	A♯	a♯⁷	b♯	C♯	D♯	*d*×	e♯	F♯⁷	f×	G♯
7♯	C♯	D♯	d♯⁷	e♯	F♯	G♯	*g*×	a♯	B⁷	b♯	C♯
6♯	F♯	G♯	g♯⁷	a♯	B	C♯	*c*×	d♯	E⁷	e♯	F♯
5♯	B	C♯	c♯⁷	d♯	E	F♯	*f*×	g♯	A⁷	a♯	B
4♯	E	F♯	f♯⁷	g♯	A	B	*b*♯	c♯	D⁷	d♯	E
3♯	A	B	b⁷	c♯	D	E	*e*♯	f♯	G⁷	g♯	A
2♯	D	E	e⁷	f♯	G	A	*a*♯	b	C⁷	c♯	D
1♯	G	A	a⁷	b	C	D	*d*♯	e	F⁷	f♯	G
♮	C	D	d⁷	e	F	G	*g*♯	a	B♭⁷	b	C
1♭	F	G	g⁷	a	B♭	C	*c*♯	d	E♭⁷	e	F
2♭	B♭	C	c⁷	d	E♭	F	*f*♯	g	A♭⁷	a	B♭
3♭	E♭	F	f⁷	g	A♭	B♭	*b*	c	D♭⁷	d	E♭
4♭	A♭	B♭	b♭⁷	c	D♭	E♭	*e*	f	G♭⁷	g	A♭
5♭	D♭	E♭	e♭⁷	f	G♭	A♭	*a*	b♭	C♭⁷	c	D♭
6♭	G♭	A♭	a♭⁷	b♭	C♭	D♭	*d*	e♭	F♭⁷	f	G♭
7♭	C♭	D♭	d♭⁷	e♭	F♭	G♭	*g*	a♭	B♭♭⁷	b♭	C♭
8♭	F♭	G♭	g♭⁷	a♭	B♭♭	C♭	*c*	d♭	E♭♭⁷	e♭	F♭
9♭	B♭♭	C♭	c♭⁷	d♭	E♭♭	F♭	*f*	g♭	A♭♭⁷	a♭	B♭♭
	Fifth.	Sixth.		7th.	Key-note.	Second.		3rd	4th		Fifth.
	Do	Re		mi	Fa	Sol		la	Se		Do

DOUBLE DIATONIC SCALE.

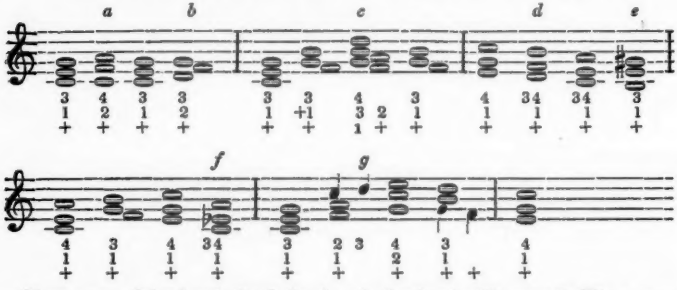
* In considering the relation of the notes in the enharmonic system, there is constant reference to the series of fifths, and the following observation of their order may be of use. A descending series of fifths is a succession of the following letters, the first four of which form an English word, viz., *bead gcf*. When the series is extended down, a flat is added, always on the beginning of this series or on *b*, which sign continues without change to *f*, where another flat comes in, remaining also for the seven letters. If the series commences with one or more sharps, the same rule holds good, remembering that a sharped note is flatted by making it natural. If then we commence with B♯ we shall have

B♯, E♯, A♯, D♯, G♯, C♯, F♯—B, E, A, D, G, C, F—B♭, E♭, A♭, D♭, G♭, C♭, F♭,

or the key-notes of the keys from twelve sharps to eight flats. Continuing, we should have a succession of the same letters, with double flats, ending with the key-note of fifteen flats; next the same with triple flats, leaving us in the unexplored regions of twenty-two flats, where for the present we will stop. The series of thirds, sevenths, etc., follow the same succession.

To the perfect sevenths is added the index ⁷, not as being essential, for the type alone is sufficient to distinguish them, but in order to make them more conspicuous at the present time.

Examples in Fingering Chords on the Enharmonic Key-board.



NOTES.—*a*, subdominant chord, f and a; *b*, dominant with seventh, F^7; *c*, same with ninth, A; *d*, dominant seventh; *e*, dominant of relative minor; the seventh, d^7 may be added; *f*, subdominant with seventh; *g*, grave second d, or sixth of subdominant. The flattened note should be made natural in the next chord.

The double figures indicate that the key is touched with one finger, which is immediately changed for another, as is customary in passing smoothly from one chord to another. The base will be easily supplied by the musician, who will also observe the similarity between this fingering, and that of the common key-board.

25. The chords given belong in part to the triple, and in part to the double diatonic scales, or more properly speaking, those scales belong to these chords. For melodies originate from harmonies, if either can be said to generate the other, when both spring into existence almost at once. When Haydn, who from poverty could not obtain instruction in the theory of music, was forced to search for himself, he discovered certain rules which he was desired to impart. "Try to find them out," is understood to have been his sensible reply. It was supposed that they referred to the dependence of melody on harmony. However this may be, it is certain by the evidence contained in his compositions, that he had a very complete and delicate knowledge of the laws of harmony and their relation to melody, and that his inspiration came from a higher source than the tempered octave of twelve keys. The student who would follow Haydn's advice will find more aid in an enharmonic key-board with its pipes, strings, or even seraphine reeds, than in the most thorough primer of thorough-base that has yet been published. A pupil in harmony taught by an instrument tempered with twelve sounds is worse off than a student of mineralogy shut up with twelve specimens, or of chemistry with so many elementary substances. The latter might learn much that is true and important, and so might the musical student would he tune his twelve notes accurately to something. And I would not be understood as thinking that those thus taught harmony are totally ignorant of its true principles; I have met with notable instances where the truth was denied in words and declared in actions. Musi-

cians sometimes learn by intuition, and contrary to what they are taught. So people are found just and amiable in spite of bad political or theological creeds and education.

26. Fig. 3 gives a section through the center of the third quarter of the key-note of fig. 2, and through all the notes, major and minor, of the signature to which it corresponds. The circumstance that a section in this place will cut all these notes and no others, might be considered remarkable and even wonderful, were it not for the fact that *this is the first principle on which the system is based.* In constructing the board a certain number of parallel spaces are laid down from left to right, and one space is assigned to each signature intended to be provided for. In the natural signature, C, the key-note, has its place of necessity. But C is the fourth of 1♯ and accordingly is prolonged backward,—toward what would be the top of a page or the north point of a map—over the space of 1♯. As it is the fifth of 1♭, and the second of 2♭, it is brought forward to cover the spaces of these two signatures also, and the whole key now is four times as long as the space originally assigned to each signature—which I have taken at nine-tenths of an inch, but which might have been more or less. So every other note wanted in a signature is placed here, and if wanted in adjoining ones it is protracted into them. Thus the e of the natural key is in all the spaces occupied by its root C, except in that of 2♭, where it is not used. The perfect sevenths and dominant thirds and sevenths of the minors being used each in one signature only, are not extended beyond it. Many simple rules for the relative position of the finger-keys could be given, which quickly fix their location in the mind, like the following:

27. *Rules.*—1. From the back half of a white key to the adjoining white key, on the right, is a *major tone,* 8 : 9, e. g., Do to Re, fig. 2, C to D, fig. 1, and *vice versâ.* 2. From the front half of a white key to the nearest black key, on the right, is a *minor tone,* 9 : 10; e. g., Re to mi, fig. 2, D to e, fig. 1, and *vice versâ.* 3. From the forward part of any black key to the adjoining white key into which it is half inserted, on the right, is a diatonic semitone, 15 : 16; e. g., mi to Fa, fig. 2, e to F, fig. 1, and *vice versâ.* 4. From the back end of any black key to the next black key on the right, is a *major tone;* e. g., la to si, fig. 2, e to f♯, fig. 1, and *vice versâ.* The distance to the right, or left, for whole tones is always the same, viz., the width of the white key or 0·993 in. Other rules will suggest themselves to the student, and these specimens will suffice.

28. The finger-keys supposed to be cut by the section A B, have their remaining portion in the rear, shown in perspective, and are marked with their names and the relative vibrations of their sounds. Below is indicated their order in the triple and

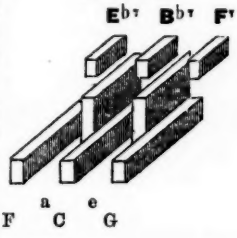
double diatonic scales. Still below is a part of a table of the fixed notes which would be cut were this section made through the key-note of the several signatures indicated in the margin. The complete table should follow below this section, but as the space of the page does not allow, it is given entire on the opposite page, and should be referred to this section; even the width of the paper on which the sounds are marked corresponds with that of the finger-key in the place it is supposed to have been cut. This enharmonic table contains in its eleven columns all the notes of the major and minor modes, within the limits of nine flats to nine sharps, both inclusive, and comprises one hundred notes to the octave. Owing, however, to the close coincidence of two of the series with two others, twenty-two of these can be dispensed with without an error exceeding the hundredth of a comma in the fifths alone, and nothing elsewhere; which difference may be neglected, and is, practically, through the "sympathy" of accordant sounds, in perfect tune.

29. The last named circumstance is of much importance when the cost of organ-pipes is in question. Although there is no such thing in music as a "circle" of keys returning into itself theoretically and mathematically, yet there are certain close approximations which can be taken advantage of for economical reasons. If we ascend eight perfect fifths and a major third, and descend five octaves, we have a note higher than our starting pitch by something less than the eleventh of a comma, or in the relation of its vibrations to the starting pitch as 100,111 to 100,000. This supposes absolutely exact tuning, which is very difficult, as the pipes or strings, when near the sound they would give when sounded singly, draw into tune, and are perfectly accordant. So that if the tuner should make his fifths one-fiftieth of a comma flat—which he might do and have them all sounding in perfect tune—he would end as much below the starting pitch as perfect tuning should, theoretically, bring him above it. From which it is seen that he can, if he choose, flat each fifth one hundredth of comma and the two series will then coincide. Indeed, this distant note is useful as a landmark, and as a detective of small errors accumulating among so many fifths. It may be compared to the correction of measured distances by astronomical observations, without, like the latter, being subject to any errors of observation however small.

30. On reference to the table, page 13, two notes thus approximate are C in the natural key and b♯, the third of eight sharps. And the key-notes B♭♭, 9 flats, to G, 1 sharp, are thus available for the thirds, from a, in 1 flat to f×, in 9 sharps; in all eleven pipes saved. Also the thirds, d♭, in 9 flats, to b, in one sharp, are equally serviceable for the dominant thirds in the minor mode, c♯ in 1 flat to a× in 9 sharps, which include eleven more pipes, reducing the hundred of the table to seventy-eight only.

31. With the key-board that has been described, all the playing is done with the hands, without aid from the feet, and there is nothing to prevent the use of the feet for pedal bases. But the same key-board is not best for fingers and for feet, especially with the large number of its sounds, many of which are not called for in pedal bases, while others are constantly required. I have therefore devised an *enharmonic pedal key-board* which is sufficient and convenient for the pedal parts. The notes most needed are the key-notes. These are arranged in front in a straight line and in the order of the fifths ascending from left to right. Behind these and in a higher row and between the key-notes are the major thirds of the keys in front and to the left of each. Still above the thirds, and directly behind the key-notes, are the perfect sevenths of the latter. The key-notes are white, the thirds black, and the sevenths red, as in the manuals. Each pedal is an inch wide and two and a half inches from center to center apart. The arrangement of the notes in the three series is as in the fig. 4, and in the following sketch:

Fig. 4.—Enharmonic Pedal Key-board.



Order of the Pedal notes.

F♭⁷ C♭⁷ G♭⁷ D♭⁷ A♭⁷ E♭⁷ B♭⁷ F⁷ C⁷ G⁷ D⁷ A⁷ E⁷ B⁷
Sevenths.

b♭ f c g d a e b f♯ c♯ g♯ d♯ a♯
Thirds.

G♭ D♭ A♭ E♭ B♭ F C G D A E B F♯ C♯
Key-notes.

32. The most important notes of a pedal base, after the key-note, are the fifth above and below; these are found here on the right and left of the key-note. The third—in the second row—is on the right of its key-note, and the tonic of the relative minor on the left. So with the relative minor: its dominant is on its right as in the major scale. If a base requires the common chord in successive notes, or in *arpeggio*, they come easily thus (Ex. 1), the keys being all together. The chord of the seventh is taken thus (Ex. 2). The diatonic scales may be played in their melodic order, Do, Re, mi, etc., without having to skip farther than the second key above or below, or a distance of five inches. Further capabilities in this key-board will appear as it is studied.

Ex. 1.

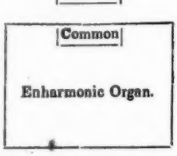
mi
Do Sol

Ex. 2.

Se
mi
Do Sol

33. Consequently, there is equal facility as in the tempered organs for managing the pedals, for the swell organ, for bringing on and taking off the stops, etc. Without considering that difficulty should stand in the way of accomplishing a desirable object which is possible and worth the expense, I would submit to those interested that it is practicable to manage an organ constructed on the principles I have proposed, and that it would give general satisfaction to the lovers of music—nearly the whole civilized world—to listen to it. I consider that the only great difficulty is in getting the requisite money applied to its cost. Still it is not impossible that some one who believes, or *knows*, what the result will be, will some time be able to build a great organ worthy of its name. If it will help its success—in view of the reluctance of organists to learn a new key-board—it might have, in addition to the enharmonic key-board, the common one with selecting apparatus, like that of the organ of 1849, to be managed by the feet of the organist, or by the fingers of the director. One of these key-boards, with the draw-stops and all necessary might be in front of the organ, facing forward, and the organist by turning on his seat could play on either, or another player could play at the same time.

ORGAN WITH TWO KEY-BOARDS, ENHARMONIC AND COMMON.



34. I propose to add to my organ—which now has the common key-board and transposition pedals—the enharmonic key-board; which will then be as represented here. But I think the new key-board alone sufficient.

35. In the theory I have advocated, the major keys are based on the first series of sounds (§ 12), and the minor keys on the sixths of the major keys, or on the series II. That there must be such a relation and order is inevitable. But respect for other authorities—among them Rev. Henry Liston, and especially Gen. T. Perronet Thompson—make it proper to mention that the major key of E may be taken on e, the third of the natural key; and that of the minor key on c, which I have assigned to the signature of three flats, may be taken on C, with the natural signature. Indeed, Mr. Liston in his organ of 1810, and Gen. Thompson in his of 1850, have this arrangement.* Musicians must decide upon the utility of taking the minor key of c upon the key-note of C major, or the scale of Ab major with C of the

* The three key-boards of Gen. Thompson's organ give respectively the keys of C, e, and d: the scale of 4♯ being based on e, the third of the natural scale, and that of 2♯ on d, the sixth of 1♭, instead of on D, the second of the scale of C. The key-notes, D and A, their thirds, f♯ and c♯, and fifths, A and E, are given; but here this series of fifths ends. B and g♯ are not embraced in the forty-two notes of his octave, in which all are employed in thirds and fifths, and none for the perfect sevenths.

natural scale as its third. If this is desirable, I have provided a finger-key at the back end of each black key, giving the minor third to the key-note, to which this black key gives the major third. For example, at the end of the key e, is **E**♭, minor third to C. This key is on a vertical wire with a circular head rising above the black key; and the whole key can be removed, if found to be in the way when not wanted. The sound, if introduced, will form a series VI (§ 12), and will require but eight extra organ pipes, whatever the number of signatures. The key-note of the ninth signature above, is but 0·09 of comma sharp for a minor third; but applying the correction (§ 30) needed for other notes, these minor thirds are made mathematically perfect. Thus the key-notes (see enharmonic table, p. 13,) C to D♯, become the series **D**♭♭ to **E**♭ (series VI, § 12), minor thirds respectively above the key-notes B♭♭ to C.

36. By transposing a scale by fifths, above or below, we first obtain a pitch widely different, and afterward approach that from which we started. For example, beginning with C we have G far removed, but in the next transposition comes D, only one diatonic interval—the tone—above C. Proceeding in the same direction, we shall ascend until at the seventh step we reach C♯, a large chromatic semitone above C. At twelve sharps B♯ is reached above C by what is called the comma of Pythagoras, or 1·09252 comma. This is the "*circle*" of the equal temperament, where the tuner divides this excess among the 12 fifths: making tolerable fifths, but intolerable substitutes for thirds. With twelve other notes for thirds, fair intervals could be had. At each successive twelve transpositions we rise by the same comma, until at fifty-three sharps the key-note is closer than ever to the starting pitch—only 0·16813 of comma sharp. If this small interval is divided among the 53 fifths, leaving each flat 0·00316 of comma, the circle will meet, and the octave will be divided into 53 equal intervals.* These are nearly exact for all the combinations of the triple diatonic scale, in these 53 keys. The fifths are as stated. The major thirds are 0·065 of comma sharp—near the limit where they draw into tune by "sympathy." In equal temperament they are sharp 0·63582.

37. The following table, page 21, serves to show: 1. this equal

* This is most readily done by its logarithm, viz., 0·00567,98112,38943,04142; which, added to itself 53 times, gives the log. of the octave, 2 : 1.

It is related that Mr. Briggs, in constructing his logarithms, in order to find the first small number, began with the number 10, and its logarithm 1, and extracted continually the root of the last number, and bisected its logarithm, till he arrived at the 53d and 54th roots and their annexed logarithms as here below: where he found that the decimals in the natural numbers are to each other in the ratio of the logarithms, or as 2 : 1.

	Numbers.	Logarithms.
53	1·00000,00000,00000,25563,82986,40064,70	0·00000,00000,00000,11102,23024,62515,65404
54	1·00000,00000,00000,12781,91493,20032,35	0·00000,00000,00000,05551,11512,31257,82702

division into 53 notes, and how each division serves for six different notes in such close approximation that the eye would take them as one; 2. the perfectly tuned notes in their order as regards acuteness of pitch; as they result from successive transpositions by sharps and by flats to the 53d degree: and 3. any other adjustment in order to economize in the number of organ-pipes.

38. If the ear is content with the thirds 0·065 of comma sharp, we can have 53 signatures in sharps, and as many in flats—106 keys—complete in all except the perfect sevenths: these will all be supplied by 53 other pipes, making 106 pipes in the octave for what mathematically requires 640.

39. But there is an arrangement by which we can have perfect thirds and all other intervals. By flatting the fifths 0·0113 of comma, as described in § 30, and adding eight pipes, we have the triple diatonic scale perfect in 53 signatures, with 61 pipes. The perfect sevenths are supplied, and the double diatonic scales completed, by 53 additional pipes. For the minor mode we require 8 pipes each for the dominant thirds and sevenths; making a total of 130 to the octave for 53 keys absolutely perfect. They can be taken above or below the natural signature, as from 26 flats to 26 sharps: or in any other connected series of signatures. We should not have the circle joining exactly, § 36, but we should have perfect intervals within these wide limits. An enharmonic key-board for 53 signatures, on the scale I have drawn, would require about four feet of width, which could be divided into two or three boards.

40. Other adjustments can be made which are favored by the closeness of the intervals, and the large range within which the differences can be divided. In a temperament of 12 sounds, the grand difficulty is to dispose of a comma among 5 intervals, viz., 4 fifths and a major third—ignoring the chord of the seventh. The third of C, e, must serve for E. In any system the sum of the errors in these 5 intervals is always exactly a comma. The mean-tone temperament gives it all to the fifths, one-fourth of a comma each, and the equal temperament, dividing but one-twelfth to each fifth, leaves the third sharp by two-thirds of a comma. Here we have a difference of only one-eleventh of a comma, and have 8 fifths among which to divide it.

41. The following table gives the names of the key-notes of 106 regular transpositions by fifths, according to common musical rules, and the number of sharps or flats in the signature of each. It gives, besides, the thirds and dominant thirds of the minor mode which are closely approximate to the key-notes, together with the signature in which each note of the two latter series is found. A column of figures ascending from 1 to 54 indicates that there are so many notes arranged in the order of

Division of the Octave into 53 intervals.

		Transposition by Sharps.						Transposition by Flats.					
		Key-notes.		Thirds.		Dom. 3ds. Rel. Minor.		Key-notes.		Thirds.		Dom. 3ds. Rel. Minor.	
		♯s in Sig.	Letters. Times sharped.	♯s in Sig.	Letters. Times sharped.	♯s in Sig.	Letters. Times sharped.	♭s in Sig.	Letters. Times flatted.	♭s in Sig.	Letters. Times flatted.	♭s in Sig.	Letters. Times flatted.
Octave, 2 : 1.	54	0	C 0♯	8	b 1♯	16	*a* 3♯	0	C 0 ♭	45	g 6♭	37	*f* 4♭
	53	41	F 6"	49	e 7"	4	*b* 1"	12	D 2"	4	c 0"	49	*g* 6"
	52	29	G 4"	37	f 6"	45	*e* 7"	24	E 4"	16	d 2"	8	*c* 0"
	51	17	A 2"	25	g 4"	33	*f* 6"	36	F 5"	28	e 4"	20	*d* 2"
	50	5	B 0"	13	a 2"	21	*g* 4"	48	G 7"	40	f 5"	32	*e* 4"
Si, Seventh, 15 : 8.	49	46	E 6"	1	b 0"	9	*a* 2"	7	C 1"	52	g 7"	44	*f* 5"
	48	34	F 5"	42	e 6"	50	*d* 8"	19	D 3"	11	c 1"	3	*b* 0"
	47	22	G 3"	30	f 5"	38	*e* 6"	31	E 5"	23	d 3"	15	*c* 1"
	46	10	A 1"	18	g 3"	26	*f* 5"	43	F 6"	35	e 5"	27	*d* 3"
43⅓ Perfect Seventh.	45	51	D 7"	6	a 1"	14	*g* 3"	2	B 1"	47	f 6"	39	*e* 5"
	44	39	E 5"	47	d 7"	2	*a* 1"	14	C 2"	6	b 1"	51	*f* 6"
	43	27	F 4"	35	e 5"	43	*d* 7"	26	D 4"	18	c 2"	10	*b* 1"
	42	15	G 2"	23	f 4"	31	*e* 5"	38	E 6"	30	d 4"	22	*c* 2"
	41	3	A 0"	11	g 2"	19	*f* 4"	50	F 7"	42	e 6"	34	*d* 4"
La, Sixth, 5 : 3.	40	44	D 6"	52	c 8"	7	*g* 2"	9	B 2"	1	a 0"	46	*e* 6"
	39	32	E 4"	40	d 6"	48	*c* 8"	21	C 3"	13	b 2"	5	*a* 0"
	38	20	F 3"	28	e 4"	36	*d* 6"	33	D 5"	25	c 3"	17	*b* 2"
	37	8	G 1"	16	f 3"	24	*e* 4"	45	E 7"	37	d 5"	29	*c* 3"
	36	49	C 7"	4	g 1"	12	*f* 3"	4	A 1"	49	e 7"	41	*d* 5b
Dom. 3d, Minor.	35	37	D 5"	45	c 7"	0	*g* 1"	16	B 3"	8	a 1"	0	*g*♯
	34	25	E 3"	33	d 5"	41	*c* 7"	28	C 4"	20	b 3"	12	*a* 1b
	33	13	F 2"	21	e 3"	29	*d* 5"	40	D 6"	32	c 4"	24	*b* 3"
Sol, Fifth, 3 : 2.	32	1	G 0"	9	f 2"	17	*e* 3"	52	B 8"	44	d 6"	36	*c* 4"
	31	42	C 6"	50	b 7"	5	*f* 2"	11	A 2"	3	g 0"	48	*d* 6"
	30	30	D 4"	38	c 6"	46	*b* 7"	23	B 4"	15	a 2"	7	*g* 0"
	29	18	E 2"	26	d 4"	34	*c* 6"	35	C 5"	27	b 4"	19	*a* 2"
	28	6	F 1"	14	e 2"	22	*d* 4"	47	D 7"	39	c 5"	31	*b* 4"
	27	47	B 6"	2	f 1"	10	*e* 2"	6	G 1"	51	d 7"	43	*c* 5b
	26	35	C 5"	43	b 6"	51	*a* 8"	18	A 3"	10	g 1"	2	*f*♯
	25	23	D 3"	31	c 5"	39	*b* 6"	30	B 5"	22	a 3"	14	*g* 1b
	24	11	E 1"	19	d 3"	27	*c* 5"	42	C 6"	34	b 5"	26	*a* 3"
Fa, Fourth, 4 : 3.	23	52	A 7"	7	e 1"	15	*d* 3"	1	F 0"	46	c 6"	38	*b* 5"
	22	40	B 5"	48	a 7"	3	*e* 1"	13	G 2"	5	f 0"	50	*c* 6"
	21	28	C 4"	36	b 5"	44	*a* 7"	25	A 4"	17	g 2"	9	*f* 0"
	20	16	D 2"	24	c 4"	32	*b* 5"	37	B 6"	29	a 4"	21	*g* 2"
	19	4	E 0"	12	d 2"	20	*c* 4"	49	C 7"	41	b 6"	33	*a* 4"
Mi, Third, 5 : 4.	18	45	A 6"	0	e 0"	8	*d* 2"	8	F 1"	0	e 0"	45	*b* 6"
	17	33	B 4"	41	a 6"	49	*g* 8"	20	G 3"	12	f 1"	4	*e* 0"
	16	21	C 3"	29	b 4"	37	*a* 6"	32	A 5"	24	g 3"	16	*f* 1"
	15	9	D 1"	17	c 3"	25	*b* 4"	44	B 7"	36	a 5"	28	*g* 3"
	14	50	G 7"	5	d 1"	13	*c* 3"	3	E 1"	48	b 7"	40	*a* 5"
	13	38	A 5"	46	g 7"	1	*d* 1"	15	F 2"	7	e 1"	52	*b* 7"
	12	26	B 3"	34	a 5"	42	*g* 7"	27	G 4"	19	f 2"	11	*c* 1"
	11	14	C 2"	22	b 3"	30	*a* 5"	39	A 6"	31	g 4"	23	*f* 2"
Re, Second, 9 : 8.	10	2	D 0"	10	c 2"	18	*b* 3"	51	B 8"	43	a 6"	35	*g* 4"
	9	43	G 6"	51	f 8"	6	*c* 2"	10	E 2"	2	d 0"	47	*a* 6"
7⅓ Dom. 7th, minor.	8	31	A 4"	39	g 6"	47	*f* 8"	22	F 3"	14	e 2"	6	*d* 0"
	7	19	B 2"	27	a 4"	35	*g* 6"	34	G 5"	26	f 3"	18	*e* 2"
	6	7	C 1"	15	b 2"	23	*a* 4"	46	A 7"	38	g 5"	30	*f* 3"
	5	48	F 7"	3	e 1"	11	*b* 2"	5	D 1"	50	a 7"	42	*g* 5 b
	4	36	G 5"	44	f 7"	52	*e* 8"	17	E 3"	9	d 1"	1	*c*♯
	3	24	A 3"	32	g 5"	40	*f* 7"	29	F 4"	21	e 3"	13	*d* 1b
	2	12	B 1"	20	a 3"	28	*g* 5"	41	G 6"	33	f 4"	25	*e* 3"
Do, Key-note.	1	0	C 0♯	8	b 1♯	16	*a* 3♯	0	C 0b	45	g 6 b	37	*f* 4♭

their acuteness or increasing rapidity of vibration. The first half of the table assigned to "transposition by sharps" is divided into three double columns, of each of which the first column gives the number of sharps in the signature where the note at its right is found in the relation of key-note, third, etc., as indicated at the head of the column. The keys in flats have three double columns arranged in like manner. In each double column the figure following the letter shows how many times this letter is sharped or flatted. We read |14|C 2♯| "signature 14 sharps, key-note C×" (C twice sharped or double sharp). |30|D 4♯| is "signature 30 sharps, key-note D× ×" (quadruple sharp).

42. Each of the 53 notes is approximate to the six which appear in the same horizontal line, and these are the sounds which are made identical by the small correction mentioned. For example, if we divide the octave into 53 equal intervals, § 36, the first note of the table—which see—will serve as (1) C, key-note of the natural signature; (2) b♯, third in 8 sharps; (3) $a^{\times\sharp}$ (triple sharp), dominant third to the minor key in 16 sharps; (4) C, as before; (5) g^{bbbbbb} (sextuple flat), the third of 45 flats; (6) f^{bbb}, dominant third in the minor of 37 flats.* And in like manner, the six notes of each line will have the same pitch.

43. Interesting relations are found in this table. Every signature has 12 sharps or flats more or less than that which precedes. And by the division into groups of 5 intervals, curious coincidences appear. At the bottom of the first column of key-notes is C: each five intervals advance the signature seven degrees, and at the notes 6, 11, 16, etc., we have C with 1, 2, 3 sharps regularly to 36, where C sextuple sharp is key-note of 49 sharps; and C has maintained its place in eight successive groups.† There are many mathematical harmonies which point to the conclusion that music should be given in its purity, and in accordance with the laws of numbers, on which all the pleasure derived from listening to it depends.

ADDITION TO § 30.—The perfect sevenths of the major key, A^{bb7} to F^{7}, answer for those of the minor key, g^{7} to $e^{\sharp\sharp7}$; and the total of pipes in the octave will be 67.

* Notes several times sharped or flatted always bear to each other the same relation as respects these signs. The thirds of C, F, and G have the same chromatic signs as their roots. Thus the third of C is e; of C♯, e♯; of C××, e××. But the thirds of D, E, A, and B have *one sharp more:* the third of D is f♯; of D××, f××♯. When these letters are flatted, the rule holds good, by changing "*one sharp more*" to "one flat less." The letters whose thirds take one sharp more—or one flat less—are B E A D (see p. 13, note). Those which do not are G C F.

† In examining the relative vibrations of the notes in a series of fifths descending in the octave below, taking C as 1, the following notes are represented by these decimals, all of which are recurring or perpetually repeated. F, $0\overline{666}$; Bb, $0\overline{333}$; Eb, $0\overline{592}$; Ab, $0\overline{790123456}$; Db, $0\overline{526748971,193415637,860082904}$. The ratio of the comma below, or c, is $0\cdot987654320,\overline{987654320}$.

Art. II.—*A Sketch of the Geology of Southwestern Iowa;* by C. A. White, M.D.

[In advance of his final report on the Geology of Iowa.]

Whatever may be the theories concerning the natural processes by which magnesian limestone has been formed, present indications strongly favor the opinion that with the close of the Subcarboniferous period its formation ceased among the rocks of Iowa. Very little limestone has been found among those rocks herein designated as the Lower Coal-measures, and the only analyses yet made of them are two, reported by Prof. Whitney, which yielded him less than one and a half per cent of the carbonate; but a considerable number of specimens of those here referred to the Upper Coal-measures have been examined by Prof. Hinrichs, the Chemist of the Survey, and in no case have they been found to contain so much as one per cent of magnesia —usually, only a trace.* A portion of these are perhaps stratigraphically equivalent with those in Missouri, which yielded Dr. Litton in one instance upward of twenty-six per cent of the carbonate.†

The dolomitization of the Devonian and Subcarboniferous rocks of Iowa is generally more complete in their northern extension, than farther to the southward. In the northern part of the state the Devonian rocks approach a true dolomite, but in the vicinities of Iowa City and Davenport, although still magnesian in part, some of the beds are tolerably pure limestone.

Parts of all the members of the Subcarboniferous series are more or less magnesian; the St. Louis limestone which forms the upper member of the series in this state, possessing that character in a marked degree in some of its beds, both in the northern and southern portions. The older rocks are so generally magnesian that no true limestone has been recognized in Iowa among those which occur between that of the lower Trenton period and the Devonian, along their outcrop; and the boring of the artesian well at Mt. Pleasant in Henry county (1125 feet deep) found the Niagara limestone and the so-called Hudson River shale possessing about the same characters as they do in the vicinity of Dubuque, two hundred miles to the northward.

* Dr. Geinitz states upon the authority of Prof. Marcou that certain of the rocks exposed at Nebraska City are dolomitic limestone, but no analyses are referred to. (See Geinitz on the "Carbonformation und Dyas in Nebraska," Dresden, 1866.) Analyses of specimens *from the same beds* on the Iowa side of the Missouri river, only twelve miles distant, show only a faint trace of magnesia.

† In the Geological reports of Missouri, Dr. Litton gives the results of fourteen analyses of Coal-measure rock, without stating whether they are from the upper, middle or lower series. Four of the analyses show no magnesia; one, a trace; one 8·90, one 8·94, and one 26·53. The average of all, excluding the last, is about two and a half per cent of the carbonate.

These facts are mentioned in this connection, for the purpose of showing more clearly the lithological contrast between the Coal-measure rocks and those beneath them, in addition to the well known facts of their unconformability, and their natural paleontological differences.

Circumstances other than those suggested by geological features to be examined, rendered it desirable that the resumption of the state geological work should commence in the southwestern part, so that no opportunity has yet presented itself to make a complete examination of the full series of Lower Coal-measure strata, since this series does not appear at all in that part of the State, because the streams there have not eroded their valleys down to it through the upper series. This remark holds true of all that region composed of the counties of Decatur, Ringgold, Taylor, Page, Fremont, Mills, Pottawatamie, Montgomery, Cass, Adams, Adair, Union and Clarke. The greater part of last season's labors were expended in these, and other counties nearer the DesMoines river, and it is to this region almost exclusively that the following remarks upon the Upper Coal-measures are intended to apply. The Upper Coal-measure rocks are also known to be largely developed in the counties of Appanoose, Warren and Madison, and in these counties, along the Chariton, South, Middle and North rivers they are seen to rest on those of the lower series, the trend of the eastern border of the upper series passing through the last named and intervening counties, in a direction coinciding very nearly with the general course of the DesMoines river.

Although the Lower Coal-measures of Iowa have not been fully examined, yet a number of interesting facts have been collected concerning them by numerous visits to different localities. It has been satisfactorily ascertained that the lower series alone exists to the northward and eastward of the DesMoines river, the upper series lying to the southward and westward of it, but not extending so far as to its immediate vicinity. No definite knowledge of the entire thickness of the lower series has yet been obtained, but from data thus far collected it is not thought to average more than one hundred and fifty feet, but in some localities it is known to be much more, probably from local thickening of the strata.

Thus in Hardin county a section has been measured which reaches two hundred feet in thickness, and the presumption is strong that this does not represent the full series. The upper half of this section is a coarse ferruginous sandstone resting upon a four-foot bed of coal, all of which, with a part of the underlying fire-clay is seen exposed upon the bank of the Iowa river. The lower half is taken from a boring at the same locality which, according to the statement of the manager and the appearance

of the material brought up, consists principally of bluish clayey shale. This boring was undertaken with the hope of finding a lower bed of coal, but was abandoned upon reaching the limestone. A remarkable fact in relation to this section, is the existence of the well defined border of the coal-field within two miles to the northeastward, where the Subcarboniferous limestone is seen well exposed. No satisfactory evidence of a disturbance of the strata could be discovered in the vicinity, and the bed of the Iowa river is the deepest point to which recent erosion has reached.

From these, and other similar facts collected along the border of the coal-field, it seems evident that the commencement of the Coal-measure epoch in Iowa found the then existing surface, whether of Subcarboniferous or Devonian rocks, very generally uneven by erosion; and not in consequence of any disturbance of the strata except the comparatively slight subsidence which caused the general unconformability before referred to. Instances of local accumulation of sandstone strata similar to that in Hardin county are not uncommon in the lower Coal-measures: those seen at Red Rock in Marion county, and below Ottumwa in Wapello county being of the same general character, and probably cotemporaneous deposits. These, and other irregular stratigraphical features in the series, will render its full elucidation a matter of some difficulty compared with similar labor in the upper series, which is composed to a large extent of limestones, and its horizons consequently more definite and extended. The lower series also, consisting as it does principally of friable sandstones and shales, presents comparatively few natural exposures of its strata, even where the drift material is not deep, and thus renders the topography of the region which it occupies readily distinguishable by the eye from that occupied by the upper series. It sems to be a well settled fact that nearly all the coal beds of the state belong to the lower series, the best beds being found in the lower part; and that this series alone can be properly designated as the productive Coal-measures of Iowa, since the upper series is now understood to contain but one bed of coal, the maximum thickness of which is only twenty inches.

Thus much by way of presenting the lithological contrast between the upper and lower Coal-measures as herein designated.

The most complete section found in all that region comprising the fifteen or sixteen counties before named, and perhaps the most complete one of the rocks of that age to be found in that state, was measured on the left valley-slope of Middle river, in the vicinity of Winterset, the county seat of Madison county. The strata of this section which are referred to the upper series, reach a thickness of one hundred and eighty feet, and are seen

resting upon a bed of bluish, shaly, impure limestone which is referred to the lower series.

Twelve miles to the northward, the last named bed is recognized upon a branch of North river, with other beds below it, which are added to the former, and the whole designated as the Madison county section. It is numbered from the top downward.

Madison County Section.

UPPER COAL-MEASURES.

No. 1.	Thin bedded yellowish limestone,	1 ft.
No. 2.	Light bluish marlite,	4 "
No. 3.	Gray, massive limestone with dull fracture,	6 "
No. 4.	Gray, regularly bedded limestone with conchoidal fracture,	12 "
No. 5.	Black, laminated, carbonaceous shale,	2 "
No. 6.	Gray limestone with marly partings like No. 4,	34 "
No. 7.	Black shale like No. 5,	2½ "
No. 8.	Regularly bedded gray limestone with many cherty layers,	15 "
No. 9.	Compact limestone with concretionary structure,	2 "
No. 10.	Limestone of varying quality—in some parts siliceous and some of the interstitial material micaceous and finely arenaceous,	16½ "
No. 11.	Impure coal,	½ "
No. 12.	Light blue marlite,	2 "
No. 13.	Bluish, concretionary limestone, breaking readily into small fragments,	5 "
No. 14.	Bluish and reddish clays,	6 "
No. 15.	Sandy, micaceous shale, with fine grained micaceous sandstone in thin layers of bluish and greenish colors,	71 "

LOWER COAL-MEASURES.

No. 16.	Bluish, shaly, impure limestone,	2 "
No. 17.	Bluish clayey shale,	13 "
No. 18.	Coal,	2½ "
	Total,	197 ft.

It is considered probable that the members of the above section from No. 13 to No. 18 inclusive are equivalent to portions of the "Middle Coal-measures" of Prof. Swallow in Missouri, where the rocks of the whole epoch are more largely developed than in Iowa; but so far as these rocks of our own state have been investigated, they do not seem to warrant any other subdivisions than those here designated as the upper and lower series. The considerations, however, which have led to this subdivision are based principally upon lithological grounds, the result of observation in Iowa alone, and should future paleontological investigations suggest a change in this respect it will of course be made.

No fossils were found in Nos. 14 and 15, yet they are known to have a wide geographical range. No. 13 seems to be somewhat local in its extent, not having been recognized outside the limits of Madison county. It contains numerous fossils, all of which seem to be somewhat dwarfed in size, two or three of the species not having been found in any other bed. No lamellibranchiates were found in it, nor in any of the beds beneath it, yet it is not improbable that they exist in both. Its fossils seem to be confined principally to gasteropods and to the spiriferoid and terebratuloid brachiopods. In the extreme southwestern corner of the county several feet of sandstone were found resting upon this bed, which is not seen at all where the section was measured. Thus it seems that both this sandstone, and No. 13 thin out in certain directions, but no indications of a true unconformability have been observed. No. 11 is a carbonaceous band, also of limited extent, not having been recognized outside the limits of the county.

The beds occurring between No. 7 and No. 11, as well as their equivalents elsewhere, are much more fossiliferous than other portions of the section. A widely extended carbo-argillaceous horizon is comprised within the vertical limits of these few beds, embracing the only bed of coal of the upper series, and also a number of associated strata which have resulted from the deposition of material that once formed a congenial habitat for lamellibranchiates and gasteropods in addition to the prevailing species of brachiopods. The two former classes of mollusks are much less numerous in all the other strata, and in the more clearly calcareous beds wherever found, the lamellibranchiates are comparatively rare and appear to be confined to the Anatinidæ. The six or seven upper members, except the carbonaceous beds, are principally calcareous, and contain few other than the more common upper Coal-measure species, being largely confined to the brachiopods.

The county of Madison contains extensive and very fine exposures of the rocks of the preceding section, but so rapidly do the six or seven upper members disappear in all directions from its center that they have not been recognized outside of its limits, except perhaps to the southeastward a short distance. Therefore these beds may be regarded as the most recent of the paleozoic rocks now known in the state. The only probable exceptions to this, are the gypsum beds of Fort Dodge, the age of which is not yet known; and a coarse-grained, friable, ferruginous sandstone, to which I have given the provisional name of Nishnabotany sandstone. The latter is found at numerous points in the region of the East Nishnabotany river, sometimes reaching a thickness of more than thirty feet, and extends down to within thirty miles of the Missouri state line. It has not been

fully investigated, but is known to lie unconformably upon the upper Coal-measure rocks of that region, and is suspected to be a part of the Dakota group of Cretaceous rocks, and therefore of Mesozoic age.

The disappearance of the upper members of the Madison county section is of course most rapid to the eastward and northward, because the drainage, as well as the borders of the formation are in those directions. They are all found exposed on Clanton's fork of Middle river, as far southward as the village of Peru, but the next exposure of rocks to the southward is on the Missouri river water-shed, and belongs to the carbo-argillaceous horizon before referred to; but its bed of coal does not appear so far eastward. This is the most northerly exposure of rocks on Grand river, and is ten miles from the one last mentioned, and five miles eastward from Afton, the county seat of Union county. Fossils are numerous here in the thin calcareous bands between the layers of carbonaceous and argillaceous shales; lamellibranchiates and gasteropods predominating. Although a hundred miles eastward from Nebraska City, it is unmistakably of the same horizon as division "C" of Prof. Marcou's section there (loc. cit.), as shown by the identity and association of fossils at both localities, as well as by their stratigraphical relations.* Following down Grand river the stream is found to have a fall amounting to a little more than the general dip of the strata, and consequently makes its exit from the state with its bed in the representative of No. 15 of the Madison county section. Immediately westward from Winterset the upper beds also disappear, but somewhat less rapidly. The first good exposure in that direction, after leaving Middle river at the west line of Madison county, is on the East Nishnabotany river, some forty miles distant; yet so simple is the geology of this region that no hesitation is felt in referring the strata there to about the horizon of Nos. 8, 9 and 10 of the preceding section, particularly since that view is corroborated by observations on intervening ground to the southward. The next important

* Of the sixty-three species described and identified from division "C" of Prof. Marcou's section at Nebraska City by Dr. Geinitz, twenty-six are lamellibranchiates, and thirteen are gasteropods, which two classes of Mollusks contain the types which are principally relied upon by those gentlemen to prove the Permian age of the rocks at Nebraska City. I regret that I cannot fully agree with Dr. Geinitz in his identification of genera and species, yet I have been able to distinguish of those described and identified by him from that division, twenty species of those lamellibranchiates, and nearly half of those gasteropods, in the above named beds on Grand river; which beds are certainly not above the middle of the upper Coal-measure series as developed near the middle of the state. I moreover find that those lamellibranchiates and gasteropods with other species, characterize the horizon before referred to; the import of which is conceived to be that when they lived, they found there a congeniat habitat, and not that the Permian period then and there commenced.

exposure in that direction is near Crescent City, a few miles above Council Bluffs, and is referred to about the horizon of No. 13 of the same section. Thus it will be seen that the line of strike is practically east and west between Madison county and the Missouri river.

It was remarked that the fall of Grand river is a little greater than the southerly dip of the strata over which it passes, so that one finds lower beds exposed as he goes down the stream. This would be expected from the fact that the stream bears a little to the eastward, obliquely across a slight westerly as well as southerly dip; but the fall of all those streams between that, and the Nishnabotany river, is almost exactly coincident with the dip of the strata, wherever they have cut their valleys through the heavy drift deposit. This is clearly seen along the Nodaway river, where the bed of coal of the horizon before referred to, reaches its greatest development, and is found a little above the water at intervals, from the northern part of Adams county, to a point a few miles within the state of Missouri. The impure limestones associated with the coal bed, along the course of this river and its branches contain, both above and below the coal, but more especially below it, very many species of fossils identical with those at the locality on Grand river just referred to, and also with those at Nebraska City, which Dr. Geinitz and Prof. Marcou refer to the Permian period. (loc. cit.)

No other rocks except those of this horizon appear along the Nodaway, but the Tarkeo has bared the equivalent of No. 15 of the previous section, in the northern part of Page county, as has also the East Nishnabotany, in Montgomery county. The lower part of the carbo-argillaceous horizon is occasionally seen in the valley slopes of those two streams, but its bed of coal is not seen west of the Nodaway, until the bluffs of the Missouri river are reached in the northwestern part of Fremont county, at the locality before mentioned, where the coal has diminished in thickness to six inches. The same bed of coal also diminishes in thickness as one goes down the Nodaway, being found only ten inches thick just within the state of Missouri; and to the eastward it thins out entirely before reaching Grand, or Middle river.

The following section was measured in Fremont county at the base of the bluffs, twelve miles northeastward from Nebraska City. It is numbered from the top downward and designated as the

Fremont County Section.

No. 1.	Thin bedded yellowish limestone, - - -	4½ ft.
No. 2.	Marly and carbonaceous shales, - - -	7 "
No. 3.	Impure coal, - - - - - - - -	½ "
No. 4.	Light bluish fire clay with fossil grasses? - -	2 "

No. 5.	Compact bluish limestone with shaly partings, -	4	ft.
No. 6.	Yellowish and bluish marlites, - - - -	6	"
No. 7.	Gray limestone with small concretions, - -	4	"
No. 8.	Unexposed, - - - - - - - -	6	"
No. 9.	Compact gray limestone, - - - - -	1½	"
No. 10.	Light yellow indurated marl, - - - -	4	"
No. 11.	Yellowish siliceous limestone with flinty masses, -	2½	"
No. 12.	Yellowish earthy shale with concretionary layers of limestone, - - - - - - - -	3	"
No. 13.	Compact, gray limestone, - - - - -	1	"
No. 14.	Yellowish earthy shale, - - - - -	2	"
No. 15.	Heavy bedded limestone, with dull fracture, -	3	"
No. 16.	Bluish shale, - - - - - - - -	½	"
No. 17.	Soft, yellowish siliceous stone, crowded with Fusulina,	1½	"
No. 18.	Massive, light gray limestone with dull fracture,	16	"
No. 19.	Bluish marlite with 9 inch band of limestone, -	4½	"
No. 20.	Compact bluish limestone with small concretions,	2	"
No. 21.	Bluish marlite, - - - - - - -	4	"
No. 22.	Bluish, thin-bedded, fine-grained, micaceous sandstone,	1½	"
	Total,	81	"

The localities of the two sections here given are nearly one hundred miles apart, yet their equivalencies are very satisfactorily determined. No. 22 of the Fremont county section is regarded as equivalent with No. 15 of the preceding one; and the remainder of the Fremont county section, as equivalent with that portion of the preceding one between the lower portion of No. 6, and the top of No. 15. No. 7 of the Madison county section is regarded as equivalent with Nos. 2 and 3 of that of Fremont county, both belonging to the carbo-argillaceous horizon before described. Beneath this horizon, and more or less associated with it, there is quite a definite Fusulina horizon, which forms a conspicuous stratigraphical feature in the southwestern counties, but since these fossils range through the entire upper series they cannot always be relied upon for stratigraphical determinations. It is quite otherwise, however, with the horizon first named, for we are able to recognize this, with more or less certainty all over the region in question, both by its bed of coal, or carbonaceous character where that does not exist, and also by its peculiar paleontological features.

The subject may be briefly summed up thus:

1. Besides the usual paleontological and lithological differences between the Coal-measure rocks and those beneath them, there seems to be in Iowa almost an entire absence of magnesia in the former rocks, while it prevails so largely in those of older date.

2. The lower Coal-measures contain nearly all the coal of the state, and are composed principally of sandstones and shales.

3. The lower Coal-measures alone are found along the Des-Moines river, and to the northward and eastward of it.

4. The upper Coal-measures lie wholly to the southward and westward of that river, the receding borders of that formation resting conformably upon the lower series. Consequently the rocks of the upper series do not reach the border of the Coal-field, nor do they ever lap upon the rocks of older date than the lower Coal-measures, as they are supposed to do in Illinois.

5. The region more particularly described in this article is comprised within that portion of the three southern tiers of counties lying between the Missouri river, and a line running southward from the city of DesMoines.

6. The rocks of this region belong principally to the upper Coal-measures, which are seen resting upon the lower Coal-measures at the eastern border.

7. A few beds of the upper series thin out, but no true unconformability is recognized.

8. The upper series is believed to contain but one bed of coal, properly speaking, the maximum thickness of which is twenty inches, and its greatest development along the Nodaway river.

9. The stratigraphy of the whole region is very simple, the line of strike being practically east and west, and the dip, to the southward nearly coincident with the fall of the streams.

10. The highest Paleozoic beds are to be found in Madison county and belong to the upper Coal-measures.

11. The lowest beds exposed along the Missouri river, or upon its water-shed within the region herein described, belong also to the upper Coal-measures as designated on the previous pages.

12. No Subcarboniferous rocks are found westward from the immediate vicinity of the DesMoines river.

13. There is a definite carbo-argillaceous horizon recognized over the greater part of this region which is characterized by the bed of coal before referred to, and in the strata of which lamellibranchiates and gasteropods prevail, and sometimes predominate.

14. Above this horizon as well as below it, characteristic upper Coal-measure brachiopods, and other fossils prevail.

15. Below this horizon the rocks increase in thickness and calcareous character from east to west, and probably also to the southward.

16. Nishnabotany sandstone occurs in the counties of Mills, Montgomery, Cass and Pottowatamie. It lies unconformably upon the upper Coal-measure rocks, and is supposed to be of Cretaceous age.

Iowa City, Iowa, March 27th, 1867.

ART. III.—*Notes on the Geology of Kansas;** by F. V. HAYDEN.

PERHAPS few portions of the globe of the same size have furnished more facts and collections of interest to scientific men, both in Geology and Paleontology, than those drained by the Missouri river and its tributaries. Since 1853 the greater part of my time has been devoted to the development of the geology and natural history of this great region. During that period I have personally examined the greater part of the territories of Kansas, of Nebraska, Dakota, Montana, Idaho and Colorado, and it is but natural that I should read with great care and interest a publication on the geology of any portion of that country emanating from any other source. It was on this account that an official report on the Geology of Kansas by Prof. Swallow was hailed with pleasure. In the summer of 1858 Mr. Meek and the writer made a careful examination of a large portion of Kansas from Leavenworth City westward to Smoky Hill, and the results of that exploration were published in the Proceedings of the Academy of Natural Sciences at Philadelphia, Jan. 1859. In that paper opinions were advanced in regard to the relations of the Permian to the Carboniferous rocks which were accepted by most of the geologists in this country and in Europe. In the report of Prof. Swallow, however, opinions have been expressed on some points opposite to those in the paper above referred to, and it is the object of this article to pass these opinions under review. Mr. Meek has furnished some carefully prepared notes which form the substance of this article.

Although Prof. Swallow acknowledges (p. 43) that these Permian strata (his Lower Permian) graduate into, and are so nearly conformable to, the Coal-measures below, that "no want of conformability can be detected by examining any one locality, though the line of junction be traced a long distance;" "Yet," he continues, "when sections are made across the line of junction at distant points, it becomes evident that there is a striking non-conformability. When the sections made across this line on the Kansas, at Manhattan and above, are compared with those on the Blue, though separated by several miles, there is no difficulty in identifying all the important strata in one with those of the others; and when these sections are compared with those at Mill Creek, some 25 miles east, and with those on the Cottonwood, 60 miles south from Manhattan, the prominent beds are easily identified down to the lowest of the Permian, No. 84 of the above section; but Nos. 85–95 from the section near Manhattan are not found, when No. 84 rests directly down

* Preliminary Report of the Geological Survey of Kansas. By G. C. SWALLOW, State Geologist. Printed at Lawrence, Kansas, 1866.

upon the *Fusulina* shales." Now the facts here mentioned, even if we admit that the very same beds have not been mistaken for others, or the contrary, from a change in their lithological characters at different localities, do not establish non-conformability as that term is used by geologists. As properly used in geology, the word unconformable is applied to two or more beds or sets of strata, resting one upon another, and dipping at different angles or in different directions in consequence of the older beds being tilted from their horizontal condition previously to the deposition of the later ones. Such disturbances or want of conformity in the planes of strata, are usually accompanied by differences in the groups of fossils above and below the line of non-conformity, and thus indicate a considerable change of physical conditions, as well as the lapses of long periods of time, between the deposition of the discordant strata; and hence are usually admitted as marking the close of one period and the introduction of another. The mere thinning out in some given direction of particular beds and thickening of others, however, may occur in any part of the same formation without indicating any such disturbances, lapse of time, or changes of physical conditions between the deposition of the beds above and below the horizon of the locally absent strata. Every one who has studied our western Coal-measures attentively, must be aware that nothing is more common than the thinning out of particular beds of considerable thickness, sometimes even between no very distantly separated localities. Lesquereux has shown this to be the case at various horizons in the Coal-measures of Kentucky, Illinois and other western States, as well as Pennsylvania. For instance, in speaking of Coals No. 1B, and 1C (Ill. Report, i, p. 216), he says they are usually separated by 55 feet of strata, but "from the absence of the strata separating these beds of coal, they sometimes come in contact, forming a single bank." Again, on page 218 of the same report in speaking of the divisions of bed B often found separated by a thin parting of clay, he mentions an instance of this parting, which is sometimes entirely wanting, swelling out from a mere seam so as to form a bed of shale 10 feet in thickness, in a distance of only 300 yards. Again (ib., p. 228), in speaking of the Colchester bed (Coal No. 3) generally separated from the conglomerate, or mill-stone grit, by from 170 to 200 feet of strata, including coals, 1B, 1C and 2, he says that, "by an apparently abnormal deposition of the Coal-measures, which I have tried to explain elsewhere, the Colchester coal almost immediately overlies the conglomerate formation," thus showing from 170 to 200 feet of intervening strata to be wanting here.

In the same Report, he has shown, that in tracing the Coal-measures a little west of north from southeastern Illinois where

this whole series is well developed, and has been clearly identified by him from its fossil plants with the Coal-measures of Europe as well as with the various members of the same formation in Indiana, Kentucky, Ohio and Pennsylvania, it is found that almost the whole of the series below the horizon of the "Anvil rock" six or seven hundred feet in thickness of the Kentucky section, has thinned out and disappeared at the northern margin of the Illinois Coal-field, so as to leave the Upper Coal-measures, and some portions of the Lower resting directly down upon Silurian rocks. Facts like the latter are evidently to be accounted for, either by supposing the northern part of the state to have been more elevated than the southern at the commencement of the coal epoch, and that as the whole area became gradually more and more depressed, the marshes, or whatever conditions gave origin to the coal, extended farther and farther northward with the formation of each successive bed; or that the southern districts sank more rapidly than the northern, and consequently received several successive beds that did not extend far northward in consequence of the greater elevation of that region at this period of their deposition. More local instances, however, like those mentioned by Prof. Swallow, of the thinning out of particular beds are evidently to be accounted for by the erosion of one or several beds in places, before the deposition of others upon them. Prof. Lesley mentions an instance of this kind in the Lower Coal-measures of Cannelton, Ia. (see Owen's Indiana Report, p. 345), where a bed of shale 46 feet in thickness thins out and entirely disappears in a distance of two miles, so as to bring directly down, upon a bed of coal, a stratum of sandstone, separated from it at another locality so near by the whole thickness of shale just mentioned. These local erosions of one or more beds previous to the deposition of others have occurred in various formations, but more particularly in the Coal-measures. On this subject Lesquereux says (note, p. 211, Ill. Report, i), "local erosions at any part of the thickness of the Coal-measures are of frequent occurrence." When we consider the conditions under which the Coal-measures were probably formed, the wonder is that such facts are not more common than the contrary. Hence we should be very cautious in viewing them as evidences of a break in the series, such as marks the close of one condition of things, and the introduction of a new epoch.

But we will now turn to the groups of fossils found in these so-called Lower Permian rocks, and see how far they sustain the opinion that there was a physical break of the importance claimed, separating them from the Upper Coal-measures. As Prof. Swallow, with few exceptions, mentions in the Report under review only by their generic or class names the fossils found in the rocks under consideration, we have to refer to his papers pub-

lished in the Transactions of the St. Louis Academy of Sciences in 1858, and in the Am. Jour. Sci., vol. xxvi, p. 182, of the same year, for his views in regard to their specific relations. In these papers he shows by a tabular arrangement the range in the various rocks of each species mentioned, as he understood them. In these lists he enumerates about 70 species of Upper Coal-measure and Permian fossils, 16 of which he shows to be common to the Upper Coal-measures and his Lower Permian, and two to the latter and the Upper Permian.

The following well known, and, with one or two exceptions, widely distributed species of our western Coal-measures, are those given by him as common to the Lower Permian and Upper Coal-measures, viz: *Productus semireticulatus*, *P. Rogersi*, *P. aequicostatus*, *Spirifer cameratus*, *S. planoconvexus*, *S. pectinifera? Chonetes Flemingii*, *Orthisina umbraculum*,* *O. Missouriensis*, *Rhynchonella Osagensis*, *Terebratula? subtilita*, *Myalina recta*, *M. subquadrata*, *M. Kansasensis*, *Allorisma Minnehaha*, and *Natica Pricei;* he also identifies with this *Macrocheilus spiratus* McCoy, a Subcarboniferous species. With the exception of *Spirifer pectinifera* Sowerby, with which we are not acquainted, and *Macrocheilus spiratus*, we know all of these common Coal-measure species occur abundantly in the so-called Lower Permian of Kansas; also the following other Coal-measure species, viz., *Aviculo-pecten occidentalis* (*Pecten Cleavlandicus* of Prof. Swallow's list), *Nautilus occidentalis* Swallow (afterward described from the Coal-measures of Illinois by McChesney under another name), *Fusulina cylindrica* in great numbers (or the Coal-measure forms generally referred to that species in the west), *Chonetes mucronata*, *Productus Calhounianus*, *Euomphalus rugosus* Hall (not Sowerby), a small *Spirifer* often referred to *S. lineatus*, *Phillipsia Cliftonensis* Shumard, and others. From the same so-called Lower Permian Prof. Swallow also positively identifies 10 European Permian species, and some 5 or 6 others with doubt; also with doubt, 1 Subcarboniferous species, 3 Triassic, and 1 Liassic European forms.

We may, however, well question the accuracy of these determinations, by which Carboniferous, Permian, Triassic and Liassic species are made to occur together in the same beds, especially in beds known to contain so many of our commonest Coal-measure species, and four genera, i. e., *Petalodus*, *Phillipsia*, *Bellerophon* and *Fusulina* not known in the Permian of Europe. Prof. Swallow says in regard to this so-called lower Permian, that the appearance at this point of numerous new fossils, many of which are well known Permian types, of the genera *Monotis*, *Bakevellia*, *Schizodus*, *Pleurophorus*, *Synocladia* and *Tham-*

* We use the names as given in the list. *Orthisina* as now restricted is a Silurian genus, and the *Natica* is a *Naticopsis*.

niscus, clearly indicates the introduction of the Permian age. The genus *Monotis*, however (as the name is here applied), also occurs far below the horizon where he would make the line of separation,—hundreds of feet, indeed down in what he includes in the Coal-measures, even near the level of the Missouri at Leavenworth, Kansas; it is also now known to occur in Illinois at a point near the horizon of the eleventh Coal-bed, above which the Coal-measures are well marked. All the other genera mentioned, and most of the very same species likewise occur in the admitted Upper Coal-measures of Kansas and the adjoining states, while *Pleurophorus* and *Schizodus* occur in the Subcarboniferous rocks of Illinois. Indeed there is now known a species of *Pleurophorus* from the Keokuk Limestone, of the Mountain Limestone series, at Warsaw, Illinois, as nearly like the European Permian, *P. costatus*, as any known form in Kansas rocks.

From all these facts, we think the evidence, both paleontological and stratigraphical, bears directly against the idea of there being a proper break in the series at the horizon mentioned by Prof. Swallow, much less "a striking non-conformity." The very fact that the missing strata, the absence of which on Mill creek is regarded as proving a break, do occur in their proper place on Kansas and Blue rivers, only 25 miles distant, shows clearly that this is one of those cases of the erosion of particular beds at certain localities, previous to the deposition of others, so common in the Coal-measures, and not one of the great general disturbances of the order of things, such as produced non-conformity of the beds, and usually accompanied the introduction of a new fauna. Nor should any great weight be given to the general lighter color of the beds above the supposed break; for every one knows how little reliance can be placed on mere color and other lithological characters in distinguishing formations.* In addition to this, the change of color is not abrupt, while lighter and darker beds continue to alternate above the supposed break, and to a less extent below it.

All the evidence sustains the opinion expressed by Meek and Hayden in 1859 (Proc. Acad. Nat. Sci., Jan. 1859), that there is in Kansas an unbroken series from the Coal-measures to the top of the Permian of this region; and that no one studying these rocks and their fossils, without any previous knowledge of the classifi-

* It may be of some interest to state here, that the matrix containing some fossils recently sent to the Smithsonian Institution by Mr. E. G. Squier, from an island in Lake Titicaca, South America, 14,500 feet above the sea, and now being studied by Mr. Meek, could not be distinguished, lithologically, from some of the Permian strata of Kansas, and the Black Hills in Nebraska. And yet these rocks in the high Andes have been referred by D'Orbigny and other eminent European authorities to the Mountain limestone. The fossils, however, from Lake Titicaca, agree in several instances with those of our western Coal-measures.

cations adopted in the old world, would have separated the Permian at all from the Coal-measures, as distinct groups. Starting far down in the Coal-measures below the supposed line of separation, we have, along with great numbers of all our common Coal-measure forms, an occasional *Monotis* (so-called), *Bakevellia*, *Pleurophorus*, *Myalina*, &c., that might apparently, in some instances, be even identified specifically with European Permian species. As we ascend in the series, we find that, after going some distance above the supposed line of demarkation, the Carboniferous species gradually begin to disappear, and the Permian types become rather more common, in particular beds, until we have ascended to a point near the horizon Prof. Swallow makes the line between the Upper and Lower Permian, when we find we have almost completely lost sight of the familiar Carboniferous species, a few of which had continued on up to near this point, and see scarcely any but forms such as in Europe would be regarded as Permian types. There is no physical break here, however, nor *abrupt* change of fossils. Hence Meek and Hayden regarded the beds below the horizon down so far as to include most, if not nearly all, of Prof. Swallow's Lower Permian, as an intermediate connecting series between the Permian and Coal-measures which, if worthy of a distinct name at all from the latter, should be called Permo-carboniferous, while the beds above, they regarded alone as properly the equivalent of the true Permian of Europe.

The occurrence of a few types that would generally be regarded as Permian, along with numerous well-known Coal-measure species, far below the true Permian, only accords with facts observed in other formations in this country, where certain types evidently made their appearance here long before they are known to have appeared in Europe. In this connection we need but refer to the Cretaceous plants of Nebraska, most of which belong to genera, and some of them to species, scarcely distinguishable from forms known in Europe in rocks not older than the later Tertiary. Even one of the best botanical paleontologists of Europe thought some of them probably identical with Miocene species, and yet they hold a position near 800 feet below beds containing numerous species of *Ammonites*, *Baculites*, *Scaphites*, *Inoceramus*, and various other unquestionably Cretaceous types. Similar facts have also been brought out by the California Survey. It is also worthy of note that in several cases these few Permian types occurring far down in the Coal-measures in Kansas appear in particular layers, similar to the Permian rocks in composition, and alternating with other beds containing only Carboniferous fossils, much like Barrande's "Colonies" in the Silurian rocks of Bohemia.

In regard to the Permian discovery in Kansas, we regret to see that Prof. Swallow (doubtless inadvertently) here in an official report, uses language, which when taken in connection with the fact that he nowhere alludes to the labors of others in that region would lead some to think he had intentionally ignored the agency of any other parties in that discovery and was claiming it as wholly his own. Thus in a note at the bottom of page 42, after speaking of the discovery of Permian rocks in Kansas, he says "this discovery was first announced by myself Feb. 22, 1858. See Trans. Acad. Sci. St. Louis, vol. i."

We had supposed the dispute in regard to this discovery was long since amicably settled, when Prof. Swallow published in this Journal, [2], vol. xxvi, page 188, in a paper on the Kansas Permian, the statement that "it is but just to state in this connection, that, so far as I know, Mr. Meek first discovered the Permian character of the Kansas fossils, and communicated to Maj. Hawn his impression on this subject on the 3d of Sept., 1857. He also mentioned his discovery, as I am informed, to some friends at the Smithsonian Institution on the 17th of January, 1858, and communicated the same to Prof. Leidy, on the 16th of March.* Maj. Hawn frankly declares that his first impressions that the rocks in question might be Permian are due to Mr. Meek." We may be mistaken; but the literal wording of Prof. Swallow's note quoted above, in connection with his silence in regard to the agency of others in this discovery, might be understood, without some explanation, as indicating an intention to claim it on the strength of the fact that his announcement, communicating the discovery to a regularly established scientific institution at an earlier date than the reading of Meek and Hayden's paper before the Albany Institute, gave him a right to claim it as entirely his own. On this ground, however, Meek and Hayden would still be in advance, for they had not only made it known verbally to friends in Washington, about the 17th of Jan., 1858, but actually had a record made of it at the Smithsonian Institution, (as all know, established for the increase and diffusion of knowledge) on the 19th of Jan., 1858. This record or memorandum, which we are permitted to give here, was written by Prof. Baird and reads as follows:—

"1858, Jan. 19th, Mr. Meek and Dr. Hayden showed me a series of fossils arranged on the table of room 110, from Dr. Hayden's collections under Lieut. Warren in 1857, which they stated

* This latter date is doubtless a misprint for 16th of Jan., for the discovery was actually published on the 4th of March, 1858, by Meek and Hayden in a paper read before the Albany Institute on the 2d of March, 1858, extras of which were distributed by them two days after, and before the issue of Prof. Swallow's paper alluded to above: though Prof. Swallow had a short time previously published a note on the subject in a St. Louis newspaper. He also published another notice in this Journal, issued, if we mistake not, between 4th and 10th of March, 1858.

to represent in succession, first, Potsdam Sandstone from the Black Hills; 2d, forms indicating Permian both in Kansas and the region of the Black Hills; 3d, fossils of the Jurassic type from the region of the Black Hills; 4th, Carboniferous from the Black Hills. (Signed) S. F. BAIRD."

This memorandum is not noted in the order the fossils were arranged; the clause in regard to the Carboniferous was accidentally omitted between the Potsdam Sandstone and the Permian, and then added at the end after the Jurassic. Nor is any mention made of the fossils sent from Kansas to Mr. Meek by Mr. Hawn, nor of a small collection from the same region communicated by Dr. Cooper which were at the same time lying on the table; though both of these gentlemen received full credit for collecting and sending these fossils, in the paper published by Meek and Hayden.

It is with considerable reluctance that this subject, which we had thought entirely settled, has been touched upon here; but the facts already mentioned seemed to demand such a statement. At the same time that Meek and Hayden manifest no desire to ignore the connection of Mr. Hawn and Prof. Swallow with the Permian discovery, they have the right to expect their own agency in the matter to be acknowledged, especially in an official report on the geology of that region, treating upon this formation and speaking of the labors of others in that connection.*

In Prof. Swallow's former papers, he gives the total thickness of the Upper and Lower Permian as he understands them, at 820 feet, and in the report under review the thickness of the same beds is given as 704 feet 1 inch. This is quite as near an

* We have made some remarks in regard to the Permian discovery in this article, not with the idea of convincing any one at all familiar with the facts of the case, for several of the ablest geologists of the present time have indicated directly or indirectly their opinion on this matter, but because our silence might be taken as entire submission to the apparent disposition on the part of some geologists to ignore our agency in the development of the geology of the West. No true-minded geologist in reading Prof. Swallow's statements under his own signature as given in this article and the note by Mr. Meek appended to a paper published in the Trans. Albany Institute, March 2d, 1858, can possibly err in regard to the *real* discoverer of the Permian in Kansas. During the year 1857, I had the good fortune to be connected as geologist, with a U. S. exploring expedition to the Black Hills under the command of Gen. G. K. Warren, U. S. A. Among some fossils I had collected at various points in the Black Hills and along the Missouri river, were forms much like those of the Permian of Europe. Maj. Hawn and Dr. Cooper had also sent to Mr. Meek collections from Kansas. In numerous letters from Mr. Meek while I was in the West he continually impressed upon me the importance of looking out for Permian fossils. In a letter dated Oct. 20th, 1857, he said he had received "some fossils sent on by Maj. Hawn evidently either Upper Coal-measure forms or *Permian*, I would not be astonished if they should prove to be the latter." Again, Nov. 10th, 1857, speaking of some fossils I had sent him from near Nebraska City, "among them I think I recognized a *Monotis* [*Pseudomonotis*], a genus not known in the old world in older rocks than the *Permian*." F. V. H.

agreement as could be expected in the measurement of such variable strata at different localities; yet when there is a difference of 116 feet, and the numerous subordinate beds composing the whole are stated as varying in thickness at different places from 1 to 15 feet, 4 to 12 feet, 10 to 25 feet, and so on, one would naturally suppose that the odd inch might have been dispensed with in summing up the whole, as it gives the appearance of minute exactness, manifestly unattainable in the measurement of such strata.

In regard to the beds referred with a ? by Prof. Swallow and Mr. Hawn to the Trias in Kansas, we can only say that they may be Trias, Permian or even Jurassic, so far as any evidence yet obtained goes. With those gentlemen we are much inclined to believe they will be found to belong to the Trias. They are known to hold a position immediately above Permian beds and beneath the Cretaceous, while they are very similar to portions of the Trias of Europe in their lithological characters. At the same time, it is by no means demonstrated that they may not prove to belong to the Permian. Prof. Swallow, at first, referred to this horizon a trilobate exogenous leaf, a small bivalve he thought doubtfully identical with *Nucula speciosa* Münster, from the Muschelkalk (not a true *Nucula* by the way), and another shell he thought identical with *Myophoria orbicularis* Goldf. (sp.) As Prof. Swallow now only alludes to the supposed *Nucula*, and makes no mention of the *Myophoria* in his report, in speaking of this rock, it is probable he has found the latter to be a *Schizodus* or some other type from the Permian; and as the trilobate leaf is now known to be from the Cretaceous, as shown by Meek and Hayden, the paleontological evidence yet obtained of the Triassic age of these beds seems to be narrowing down to a single little bivalve, of doubtful genus. It is true Prof. Mudge thinks he has found bird tracks in a sandstone of this horizon, but as he also speaks of finding exogenous leaves in the same position, it seems probable that the tracks mentioned by him are from the sandstone belonging to the Cretaceous, in which so many leaves have been found in that region. We must therefore await further evidence before we can regard the existence of the Trias in eastern Kansas as demonstrated.

ART. IV.—*On the systematic value of Rhynchophorous Coleoptera:* —an Abstract of a Memoir read before the National Academy of Sciences, at Washington, Jan. 24th, 1867; by JOHN L. LECONTE, M.D.

IN the empirical arrangement of the families of Coleoptera, which has resulted from the adoption of the tarsal system of division, the families contained in the great natural group of Heteromera are followed by the Curculionidæ and Scolytidæ, which, more or less subdivided into smaller families, have been supposed to establish a linear relation between the rostrated Heteromera (Salpingus, Rhinosimus, &c.) to the Cerambycidæ and Chrysomelidæ, the great types of the Pseudotetramera, or Subpentamera, of various authors.

It is the object of the present investigation to determine the limits, and the relations of the first mentioned of these types, the Rhynchophora.

The inferiority of this type is manifested, not only in the larval condition by the limited number or absence of visual lenses, the want of locomotive appendages, the feeble development or entire want of antennæ, and the unchitinized epidermis; but also by the combination in the imago of characters belonging to a perfectly developed organism with others pertaining to an inferior grade in the scale of Coleoptera.

Thus, for instance, while we perceive in the other series of beetles, that the lower forms retain certain larval characters, as evidenced by the extension of the coxæ, the imperfection of the anterior coxal cavities, the softness of the integuments, and the want of centralization in the abdomen, all such degradational characters are absent in the Rhynchophora.

Other characters representing low grades in their respective series do not appear in the Rhynchophora, such as vegetative growth of the organs of sense, indicated by pectinate or flabellate antennæ, or excessive length of palpi.

On the contrary, we find in the Rhynchophora, that the integuments are perfectly chitinized: the elytra never abbreviated or wanting; the anterior coxæ are always completely enclosed; the ventral segments, usually five, never exceed six in number.

The plan of degradation, in passing from the higher to the lower forms, is by the extension of the longitudinal axis of the body, in its anterior half; this is usually most strongly manifested in the head, and exhibited not only by the length of the beak, but by the conformation of the lower floor of the mouth.

Commencing with those Curculionidæ (Adelognathi *Lacordaire*,) in which the mentum fills the gular emargination, as in the

higher Tenebrionidæ, we find a gradual lessening in size of the mentum, itself becoming supported upon a broad, short, gular peduncle, permitting the maxillæ to become visible, (Phanerognathi, Cohort 1, *Lacordaire*): next the gular peduncle becomes elongated, and bilobed, receiving the mentum, now reduced to very small size, between its lobes (Phanerognathi, Cohort 11, and also Brenthidæ, and Anthribidæ).

Having in the continuance of my work on the Classification of Coleoptera of North America, recently commenced a critical study of our Rhynchophora, I became aware of the impossibility of intercalating them between the Heteromera and Subpentamera, and am now convinced that they represent a special type, which must be isolated from all other types of Coleoptera, possessing a systematic value equal to all the others combined.

In seeking for the characters which should define this type, I observed a remarkable difference in the arrangement of the pieces of the under surface of the prothorax, heretofore overlooked, and so far as I know, confined to this particular type.

In other Coleoptera, the prosternum is either extended behind the anterior coxæ, so as to form part of the hind margin of the segment, thus coming in contact with the mesosternum, or it is cut off between the coxæ, and in this case (as in many others) the coxal cavities are open behind: in the few exceptions (Derodontus, Dacoderus) in which the coxæ are contiguous and the cavities closed behind, the prosternum still extends behind the coxæ, to the hind margin of the segment, as is shown by the short sutures separating the epimera from the medial piece of the prosternum.

I have represented these modifications of form in the adjoining wood-cuts. Fig. 1, under surface of prothorax of a Carabide

(Pasimachus); the coxal cavities are closed, and the epimera and episterna well defined. Fig. 2, do. of a Scarabæide (Lachnoster-

na): the coxæ are transverse, the cavities closed, the side pieces not distinct. Fig. 3, do. of Cucujus; coxal cavities open behind, side pieces not distinct. Fig. 4, do. of Telephorus: coxal cavities confluent and open behind.

In Rhynchophora the prothoracic sutures are obliterated, there is no separation between the prosternum and episterna, and very rarely between the latter and the pronotum: the coxal cavities, frequently confluent, are always closed behind, *by the epimera*, which become connate on the median line, enclosing the hind part of the prosternum, thus cutting it off completely from the mesothoracic segment.

Fig. 5 represents this arrangement of parts in a Brenthide, in which family the extreme limit of degradation by linear extension is reached. Fig. 6, under surface of prothorax of a Calandride (Rhynchophorus). Fig. 7, do. of Cryptorhynchus. Fig. 8, do. of Balaninus. Fig. 9, do. Ophryastes. Fig. 10, do. Thecesternus. Fig. 11, do. Dendroctonus.

When the coxæ are contiguous, the point of the prosternum is visible behind them, but is none the less perfectly enclosed by the growth of the side pieces to the median line.

Another evidence of the inferiority of type of the Rhynchophora, which has not been mentioned, is seen in the functions performed by the beak, which in the lower groups, especially in the female, becomes greatly elongated. The occurrence of corneous exserted ovipositors in other orders of insects is not rare: a few species of Coleoptera (certain Valgus, for example) have the last abdominal segment prolonged, simulating such an organ. But it was reserved for the Rhynchophora to exhibit a degradation of type, by which a function, peculiarly appropriate to the posterior extremity of the body, is performed by the head: the elongated beak becoming in fact the ovipositor.

Thus the inferiority of grade, evidenced in other series of Coleoptera by the softness of the integuments, or by the permanence of larval forms, chiefly in the abdomen and coxæ, is in the Rhynchophora manifested by the transfer of a function from the posterior to the anterior part of the body, and the linear extension of the latter, in accordance with this 'change of base.'

The principles of classification of Rhynchophora, and their division into families will be discussed in a subsequent memoir. It is, however, proper to observe that the peculiar construction of prothorax above described as characteristic of the Rhynchophora, is not exhibited in the Bruchidæ, which family, as observed by Lacordaire (Gen. Col. vii, 600), should be viewed as closely related to, if not actually a portion of, the great family Chrysomelidæ.

ART. V.—*On the Morphological value and relations of the Human Hand;* by BURT G. WILDER, S.B., M.D.

[Abstract of a paper read before the National Academy of Sciences, Aug. 8, 1866.]

THE morphological relations of the human hand are of three kinds.

1st, Its *special homology* with the terminal segment of the anterior extremity in other vertebrates.

2d, Its *general homology* as a part of the skeleton; which can be fully enunciated only after a decision as to the morphological relations of the scapular arch of which it is an appendage.

3d, Its *polar homologies* with the corresponding parts on the *opposite side* and at the *opposite end* of the body. That with the other hand is universally regarded as one of *symmetry* or *antagonism;* that with the foot is generally called its *serial* homology, and the point under consideration is whether this is merely a serial relation and not rather one of antagonism, so as to constitute a second kind of polar homology.

The course of the argument is indicated by the following propositions.

1. The extreme diversity and confliction of opinion* as to the morphological *relations* of the human hand are chiefly due to an over-estimate of its morphological *value.*

2. This misappreciation of the morphological value of the hand is due to a non-recognition of the distinctions between the two principles, morphology and teleology.

3. Morphology is the law of internal form, of plan, of essential structure. Teleology is the law of special function which determines size, shape and general appearance.

4. Homology is morphological identity; analogy is teleological resemblance: and neither relation necessarily implies the other.

5. Morphology treats of unity of type; teleology treats of adaptation to ends.

6. Morphology alone would be law without liberty, which is despotism; teleology alone would be liberty without law, which is anarchy.

7. Morphology is conservative and tends toward centralization; teleology is radical and tends toward diffusion.

8. The two principles may be traced in all structures, but the one is often more prominent than the other.

9. With certain important qualifications it may be said that the clearest manifestations of morphology are to be observed in

* Some idea of this diversity of opinion may be gained by reference to Dr. Cleland's brief statement of the views of various authors in the 7th edition of Quain's Anatomy, pp. 115–117, 1866, and to the remarks of Mivart, Linnæan Transactions, vol. xxv, p. 400.

organs which are *central* or *proximal*, *simple*, *rudimentary*, and *constant;* while teleology displays itself in organs which are *peripheral* or *distal*, *complicated* and *subject to variation.*

10. Man is the most perfect animal in a functional point of view, and the hand is *peripheral in its position*, *complicated in function* and *subject to variation* both in the zoological series and by arrest or excess of development: and forasmuch as it has, during all ages and by all classes of minds, been regarded as a typical illustration of perfection of detail and harmonious arrangement of parts in strict conformity to the elevated offices which it performs, *therefore to the same extent must we disregard it in our endeavor to determine questions of morphology.*

11. Hands and feet, but especially the former, are as unsafe guides to the homology of the limbs, as the cranial and caudal regions would be to the characters of a typical vertebra.*

12. In discussing the relation between the fore and hind limbs, we must free our morphological comparison from all consideration of special function.

13. The fore and hind limbs are appendages of the anterior and posterior regions of the body; and whatever general laws are observed in the body, are, on *a priori* grounds, to be looked for in the limbs.

14. Polarity, or something analogous to the polar forces of physical science, is a primary law in the formation, the structure and the general functions of the vertebrate body;† for the existence of this, evidence is furnished by embryology, anatomy, physiology, and pathology.‡

15. The anterior and posterior regions of the body are, as it were, the two poles of a longitudinal axis, and their constituent parts are more or less completely homologous, repeating each other in opposite directions like the corresponding organs upon the right and left sides.

16. This polar or antagonistic relation of similar parts may easily be traced in the proximal segments of the limbs in many mammalia; the front of the thigh and the convexity of the knee are readily compared with the back of the upper arm and the convexity of the elbow.

17. Of the two pair of limbs, the anterior is the more subject to variation and is therefore less reliable for morphological purposes.

* On a cat with supernumerary digits; Proceedings Bost. Soc. of Nat. Hist., May 16, 1866.

† See the writings of Oken: also description of a double fœtus, by Prof. Jeffries Wyman, Bost. Med. and Surg. Journal, March 29, 1866; and classification of Herbivores, and Cephalization, by Prof. James D. Dana, this Journal, vol. xxxvii, p. 158, and vol. xli, p. 164.

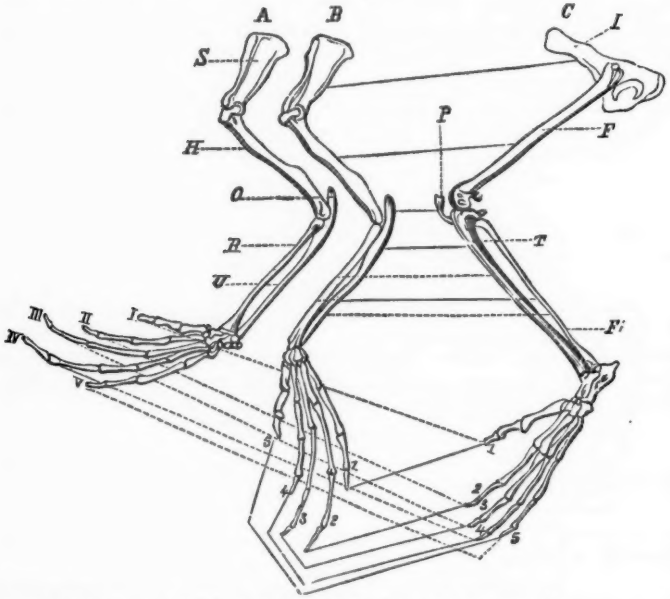
‡ See paper by the writer on Pathological Polarity, Bost. Med. and Surg. Journal, April 5, 1866, and on Morphology and Teleology especially in the limbs of Mammalia, Memoirs Bost. Soc. Nat. Hist., vol. i, No. 1, 1865.

18. By reference to the less modified hinder limb we find that, as a rule, *two contiguous segments bend in opposite directions.*

19. By comparing the proximal segments of the hinder limb with those of the fore limb, we find that *two corresponding segments in the two limbs point and are flexed in opposite directions.*

20. Conformity with these two rules is all that would be necessary for maintaining the *balance* of a *geometrical figure* or a *stationary being;* but to enable an animal to *move*, the terminal segments of both limbs must face in the same direction; in the quadrupeds this is usually accomplished by a rotation of the radius upon the ulna so as to face the palm backward, or as in the Aye-aye *inward*, like the sole.

Limbs of left side of Aye-aye (*Cheiromys Madagascariensis* Cuv.), (altered from Owen.)*



A, Fore-leg in *natural attitude*, the hand being more or less *pronated.*

B, Fore-leg in *normal position*, the hand *supinated* so as to be symmetrical with the foot.

C, Hind-leg. S, Scapula; I, Ilium; H, Humerus; F, Femur; O, Olecranon; P, Patella; U, Ulna; T, Tibia; R, Radius; Fi, Fibula.

Homologous parts are joined by continuous lines. Analogous parts are joined by dotted lines. The homologous digits of B and C are numbered 1, 2, 3, 4, 5, starting from the so-called little finger and great toe. The Roman numerals attached to the digits of A indicate their analogies with those of C.

* Monograph of the Aye-aye, plate vii: Comp. Anat. and Physiology of Vertebrates, vol. ii, fig. 343.

21. This is the *natural attitude* of the terminal segments of the fore-limb, but that it is not a *normal position** in which they may be compared with their posterior representatives, is seen from their want of conformity to the principles manifested by the less modified hinder limb and by its own proximal segments (Propositions 18 and 19), and also from the more or less complete crossing of the two bones of the fore-arm, while those of the leg are parallel with each other.

22. These three discrepancies are wholly removed by *supinating the hand* and placing it, *palm downward with the fingers pointing backward* and the *wrist in front* just as the toes point forward and the heel is behind.

23. The *ulna* is now wholly upon the *inner* side of the fore-arm and corresponds to the *tibia* while the *radius* corresponds to the *fibula;* their variations as to size and shape and their being soldered together in many species are all teleological modifications and ought not to enter into the discussion of a morphological relation.

24. The *thumb* is thus left upon the outer side of the hand and corresponds by position with the *little toe*, while the *little finger* is upon the inner side and corresponds with the *great toe.*

25. These correspondences are, in my opinion, the true *homologies* while the relation between the ulna and fibula, the radius and tibia, the thumb and great toe are merely *analogies* and dependent upon teleological modifications.

The paper contained a more extended discussion of some points and a review of the later European memoirs upon the subject; but in the hope that we may shortly be favored with the views of Prof. Jeffries Wyman upon the important questions involved, the writer confines himself for the present to the foregoing abstract with the following additions as the result of subsequent investigations.

A. The conclusion reached as to the normal position and homology of the thumb, though contrary to the common opinion, is confirmed by all purely morphological considerations.

B. The lack of exact correspondence between the carpal and tarsal bones in most mammalia and between the nerves and the arteries in the human hand and foot where alone they have been compared, is due to teleological modifications, the necessity for which is yet to be explained.

C. The difference in the number of phalanges, which has always been looked upon as a very essential distinction between the thumb and great toe and the other digits, is really, like the

* For a forcible statement of the necessity for distinguishing between the natural attitude and the normal position of animals, see Agassiz's contributions to the Nat. Hist. of U. S., vol. iii, part 1, p. 76; it throws a great light upon this relation of the limbs.

generic variations as to the number of the digits themselves, a difference of *quantity* and therefore teleological in its character.

D. Finally, even if there were not many vertebrates in which this difference does not exist, and if there were not on record several cases of human thumbs having three phalanges, yet, unless we are prepared to sacrifice position to quantity, we have no more reason for denying the homology of the thumb and great toe with the little toe and little finger respectively than we have for denying a homology between the third finger of man and that of a whale because the former has some additional phalanges, or between the foot of man and that of a dog because the former is composed of five digits while the latter has but four.

ART. VI.—*On the Classification of the subdivisions of McCoy's Genus Athyris, as determined by the laws of Zoological Nomenclature;* by E. BILLINGS, Paleontologist of the Geological Survey of Canada.

[Read before the Nat. Hist. Soc., Montreal, March 25, 1867.]*

EVERY naturalist who has studied the paleozoic brachiopoda is aware that there exists a very great diversity of opinion with regard to the classification of the several sections into which the old genus *Athyris* has been divided. The arrangement which I and some others have adopted is, in substance, the same as that proposed by Mr. Davidson in the first edition of his "General Introduction," published in 1853.† Although this has been ob-

* After the reading of this paper the subject was discussed by some of the members of the Society. The following is from a short report published in the newspapers at Montreal: "After the paper was read, Dr. P. P. Carpenter said that he thought that Mr. Billings had clearly established his point, and gave an account of the history of a committee appointed by the British Association to make laws to regulate scientific nomenclature, of which committee he was a member. Mr. Whiteaves stated that he was satisfied with the correctness of the view Mr. Billings had taken, and made some remarks about scientific nomenclature, and upon some structural points in the shells of the genus in question. Principal Dawson deplored the confusion that has arisen through conflicting views on the question of nomenclature, and agreeing with Mr. Billings in the conclusion he had come to, said that this communication was valuable inasmuch as it cleared up a question that had hitherto been rendered obscure."

† Modified by separating *Merista* thus:

Genus.	Type.
Athyris McCoy, 1844,	*A. tumida* Dalman.
Spirigera D'Orbigny, 1847,	*S. concentrica* von Buch.
Merista Suess, 1851,	*M. Herculea* Barrande.

The recent classification differs from the above as follows:

Meristella Hall, 1860,	*A. tumida.*
Athyris or *Spirigera*,	*S. concentrica.*
Merista,	*M. Herculea.*

According to this, either *Athyris* or *Spirigera* must be suppressed, in order to make room for *Meristella*. See this Jour., [2], xxxi, 292, xxxiii, xxxvi, ii.

jected to by several distinguished paleontologists, and in consequence thereof, abandoned by its author, yet I believe that on a careful examination of all the circumstances, it will be found to be perfectly just toward the parties concerned, and in no respect inconsistent with the rules of zoological nomenclature. It was the first subdivision of the genus published, and should therefore take precedence over all others.

Previously to 1853, *Athyris* was only known as a single large genus of brachiopoda which included such forms as *Terebratula concentrica* von Buch, *T. tumida* Dalman, and *T. Herculea* Barrande. In that year Mr. Davidson divided it into two smaller genera, confining the name *Athyris* to that section for which it was most appropriate, with *tumida* or *Herculea* for the types; and adopting *Spirigera* D'Orbigny for the other type, *T. concentrica*. It was afterward found that *Athyris*, as then re-defined, included two genera, and in consequence it has been again divided by separating all those typified by *T. Herculea* under the name of *Merista*, a genus proposed, but not clearly characterized by Prof. Suess, in 1851. This is the classification which I believe to be the true one. While discussing it I shall, throughout this paper, when I may have occasion to refer to the species above-named, designate them, *Athyris tumida*, *Spirigera concentrica*, and *Merista Herculea*.

Those who are opposed to this arrangement contend, that as all the species which McCoy placed in the genus, at the time he first described it, belong to the group typified by *S. concentrica*, the name *Athyris* must be retained for that group, and cannot now be transferred to the other section of which *A. tumida* is the type. This reasoning, according to my views, can only hold good in case it be first proved that McCoy specially confined the genus to species having the generic characters of those in his original list, or pointed out one of them as the type, or drew up his diagnosis in such a manner as to exclude *A. tumida*. In this paper I shall endeavor to show:—

1. That McCoy did not limit his genus to the species first placed in it.

2. That on the contrary he and other naturalists understood it to include both *A. tumida* and *S. concentrica*.

3. That according to the laws of zoological nomenclature the subdivision made by Davidson in 1853 cannot be set aside.

4. That Davidson's classification has been adopted into several works, some of them of great influence and wide circulation.

In order to prove the above propositions, I shall give the more important facts of the history of the genus, with McCoy's original figure, and shall quote some of the laws above mentioned in full. Much of this, of course, belongs to the common stock of knowledge of all paleontologists conversant with the fossils of the older

rocks, and might be thought superfluous. But the question is somewhat complicated and cannot well be decided, unless in view of all the circumstances. Besides this, it is one upon which any good naturalist is perfectly competent to give an opinion, although specially engaged in other departments. Few of these have access to works on paleozoic fossils, and therefore for the convenience of such as may feel inclined to investigate the subject, it is desirable to bring all the facts togather.

There is no dispute about the extent of the genera, and therefore, the details of the internal characters need not be given. It is purely a question of Natural-History Ethics, if I may be permitted to use such a term.

1. *History and extent of the original Genus.*—The original description was published in the "Synopsis of the Carboniferous Fossils of Ireland" in 1844. From this work I shall make some extracts, and shall introduce along with the original figure two others to further illustrate the subject.

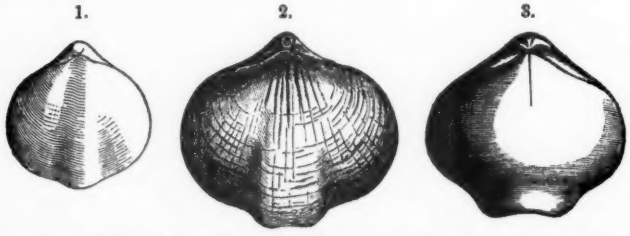


Fig. 1—Copy of the original figure given by McCoy (without a specific name) to illustrate his idea of the general form of an *Athyris*.

Fig. 2—*Spirigera concentrica* von Buch. The form is copied from Davidson's Monograph of the British Devonian Brachiopoda, pl. III, fig. 13, Pal. Soc. for 1862. The right-hand side is, in this copy, a little restored, and the aperture in the beak made larger than it is in the original figure.

Fig. 3—*Athyris tumida* Dalman. Copied from Davidson's "General Introduction," pl. VI, fig. 73.

The following extracts are from McCoy's work above referred to:—

"The family *Delthyridæ* appears to be divided into the five following genera: 1. *Spirifera* Sow., composed of those longitudinally-ribbed species, in which the hinge-line is equal to, or exceeds the width of the shell, the cardinal area with parallel sides, the cardinal teeth of the ventral valve (now called the dorsal valve) large, spirally rolled, and having a triangular foramen beneath the beak of the dorsal (ventral) valve. 2. *Martinia* McCoy, or the smooth Spirifers, in which the hinge-line is less than the width of the shell, and the cardinal area triangular. 3. *Athyris* McCoy, in which there is no vestige of either foramen, cardinal area, or hinge-line. This remarkable genus is frequently confounded with those shells usually named *Terebratula*, in the older rocks, but is distinguished by the large, spiral appendages, which are wanting in the

other group. 4. *Brachythyris* McCoy, in which we find the longitudinally-ribbed surface of *Spirifera*, united with the short hinge-line of *Martinia*. 5. *Orthis* Dal., in which there are no spiral appendages, the hinge-line and striæ frequently spinose (as in *Leptæna*), and the cardinal area common to both valves, and its sides inclined toward each other at its angles; dorsal valve smallest."—*Op. cit.*, page 128.

On page 146 of the same work, he thus concisely describes the genus:—

"*Gen. Ch.*—Nearly orbicular, small; no cardinal area or hinge-line; spiral appendages very large, filling the greater part of the shell.

"This very interesting group possesses all the external characters of the *Terebratulidæ*, united to the internal structure of the Spirifers, to which latter family it truly belongs. Professor Phillips is the only author who has recognized the group: he forms of it his last division of the genus *Spirifera*, but gives no characters to distinguish it from *Terebratula*; the internal structure is, however, a sure guide."

The above is all that he wrote about the genus at that time; and it will be perceived, that he does not point out any particular species, as the type: and farther, that there is nothing in his remarks from which it can be inferred that he knew anything about the genera into which the group was afterwards subdivided. Consequently, it is impossible that he could have intended to confine the genus to any one of them; as is now affirmed by some of the naturalists who are opposed to the classification advocated in this paper. Instead of excluding species with an imperforate beak such as *A. tumida*, the etymology of the word *Athyris* (without a door or opening), the expression, "in which there is no vestige of either foramen, cardinal area or hinge-line," and, also, his typical figure all induce the belief that he had before him one or more forms with the beak entire. This is rendered certain by what he says on page 147. Speaking of what he calls *A. concentrica*, he says: "This species is not uncommon; it is figured in the Bull. de la Soc. Géol. de France, with a perforated beak as in *Terebratula*. I have, however, seen numerous specimens with the beak entire and imperforate, as in the other Paleozoic species." It is highly probable from all this that he had in view such Silurian forms as *A. tumida*. This latter species is so common that it is almost certain that such a collection, as he was then engaged upon, would contain one or more specimens.

If we take the paragraph (No. 3) as a part of the generic description, then *A. tumida* is included. If, on the other hand, we confine ourselves to the extract from p. 146, it is not excluded, as there is no reference made there to the structure of the beak. This latter diagnosis is sufficiently comprehensive and general in its terms to include *Athyris*, *Spirigera* and *Merista*. He did not place *A. tumida* in the genus, for the reason that his

work was confined altogether to the Carboniferous fossils, among which it does not occur. But he did so afterward when he described Professor Sedgwick's Silurian fossils, as will be shown farther on. He was wrong in supposing that all the species were imperforate, a matter of little consequence, as it was simply an error of observation which does not vitiate. Had the genus turned out to be not capable of subdivision, all that could be done now with this error would be to strike it out. There was sufficient in his diagnosis to indicate what group of fossils was intended. He was also wrong in supposing *S. concentrica* to be a Carboniferous fossil: it is Devonian. It may be that he mistook some other species with an imperforate beak for that. It will be seen farther on that Prof. King made a similar mistake with respect to this very species, having taken *T. scalprum* Barrande, for it; an error which was detected by Mr. Davidson. Altogether, he referred eleven species to the genus, several of which have been shown to be synonyms.

In the same work he proposed another genus, *Actinoconchus*, but as it was founded on error, he afterward withdrew it, and added it to *Athyris*. (Brit. Pal. Foss., p. 436). All scientific works abound more or less with such misconceptions.

That the genus was understood by other naturalists to include *A. tumida* is proved by the following facts. It is well known that the genus *Spirigera* was proposed by D'Orbigny, in 1847, simply as a substitute for *Athyris*, on the ground that this latter name implies the absence of a foramen, and is, therefore, not appropriate for species with a perforated beak. It is quite clear that D'Orbigny considered his genus to be precisely the same in extent as *Athyris*. All the species, therefore, which he placed in *Spirigera* he regarded to be fairly within the group, and it is unquestionable that he would have referred them all to *Athyris* had not that name appeared to him objectionable. I have not seen his original description in the "Annales des Sciences Naturelles," referred to by Mr. Davidson, in the extract given below, but in the "Paléontologie Française," vol. iv, page 357, he says: "This division has already two generic names which we cannot preserve, because they are in complete contradiction with zoological characters." The two genera referred to were *Athyris* and *Actinoconchus*.

He specially selected *T. concentrica** for the type of his genus, and therefore if *Spirigera* be retained at all it must be for that section. He refers to his "Prodrome" for a list of the species, and we have thus only to examine this list in order to ascertain his idea of the extent of the genus. They are the following, taking them in the order in which they are published:

* "Le type est *T. concentrica* de Buch. Toutes les espèces avec leur synonymie se trouvent dans notre *Prodrome de paléontologie stratigraphique*."

S. Ceres, vultur, Circe, passer, Herculea, harpya, Hecate, tumida, concentrica, Helmerseni, Puschana, decussata, plebeia, Ferronesensis, Ezquerra, Hispanica, Toreno, subconcentrica, Pelapayensis, Campomanensis, Mayendorfi, Roissyi, serpentina, lamellosa, ambigua, Blodena, planosulcata, expansa, pentaëdra, pectinifera, trigonella, quinquecostata, quadricostata, tricostata and *cristigalli.*

Several of the above species do not belong to the group. This list shows that D'Orbigny regarded the genus as including not only the types of *Athyris* and *Spirigera* but also that of the genus *Merista* (*M. Herculea*) which I shall notice farther on. I think it quite certain that had D'Orbigny been aware that the genus was capable of subdivision, he would have retained *Athyris* for one of the groups which have the beak imperforate. Indeed, according to the laws of nomenclature, he could not have done otherwise with any probability of producing a permanent classification.

In a valuable paper, read before the Geological Society of France, in May, 1848, on the Brachiopoda of the Upper Silurian rocks of England,* Mr. Davidson made the following observations on D'Orbigny's genus:

Vient ensuite le genre *Spirigera* que le même auteur établit pour les coquilles qui possédent des spires internes placés de la même manière qué les *Spirifer*, mais qui ont des appendices et des détails d'organisation essentiellement différents. Ces espèces, parmi lesquelles nous trouvons les *Terebratula, tumida, Circe, concentrica, subconcentrica, Roissyi, pectinifera, ambigua, Helmerseni, Pelapayensis, Campomanensis, Ferronesensis, Ezquerra, Hispanica*, ont déjà été distinguées par M. de Verneuil comme devant former une section à part, qu'il a nommée la section des *Concentricæ*. Je suis de l'opinion de M. d'Orbigny qu'elles doivent constituer un genre. L'étude minutieuse que M. Bouchard a faite de la *Terebratula concentrica* ne m'en laisse aucun doute; mais ce genre n'ayant pas encore été convenablement caractérisé, je m'abstiendrai de l'adopter dans ce petit mémoire qui n'est pour ainsi dire qu'un résumé d'un plus grand travail que je publie en ce moment dans le *London Geological Journal.*

Upon the above I shall only remark that it is quite clear that Mr. Davidson then regarded *S. concentrica* and *A. tumida* as congeneric; and that whatever new genus might be established, it would include both species.

In 1852, McCoy, in the 2nd Fasciculus of the "British Paleozoic Fossils," page 196, re-defined *Athyris* as follows:—

"*Gen. Ch.*—Nearly orbicular or ovate, both valves convex; no cardinal area, foramen, or hinge-line: spiral appendages to beak of entering valve very large, nearly filling the shell; a strong mesial septum in the rostral part of entering valve; dental lamellæ moderate; tissue of shell apparently fibrous.

* *Mémoire sur les Brachiopodes du Système Silurien supérieur d'Angleterre*, par M. Th. Davidson, Bull. Geol. Soc. Fr., v, pp. 309, 314.

"One specimen (of *A. tumida*) shows the pallial and ovarian impressions to be thick, numerous, and dichotomising frequently from beak to margin."

In the work cited and in the 3d Fasciculus, we find the following species:—*A. tumida, S. concentrica, ambigua, De Roissyi, expansa, globistriata, globularis, gregaria, paradoxa, pectinifera,* and *squamigera.* This shows clearly enough his views of the extent of the genus, that is to say, that as it was then understood, it included both *A. tumida* and *A. concentrica.* In commenting on this, Prof. Hall says:—"The fact that McCoy cited this* as an Athyris, no more renders it an *Athyris* than it was made *Atrypa*, by being thus described by Dalman; and it was just as free for the foundation of a genus after the citation of McCoy as before." This is true enough, in part. It was free for the foundation of a genus until 1853, when Davidson used it for that purpose; but since 1853, it has never been free.

The above is quite sufficient to prove my first and second propositions.

I am not aware that any thing else of much importance, with the exception of what relates to *Merista*, having been published up to 1853, when Davidson's excellent work, the "Introduction to the Classification of the Brachiopoda," made its appearance, in which the genus was first subdivided. But, before entering upon this, I shall notice the remarks of Prof. Suess, on the genus *Merista.*

This genus was proposed by Prof. Suess, in 1851, but he did not then sufficiently characterize it. The following is all that I can find, relating to it, that was published previously to 1853.

"Mr. E. Suess communicated the results of the investigations on several Brachiopods, from the Bohemian transition rocks, which had been made by him and Mr. Custos Dormitzer, of Prague. He showed that some of the forms heretofore referred to *Terebratula* had no opening in the beak, for the passage of the muscle of adhesion; and, also, that the distribution of their inner organs points to an affinity with the non-attached genus Pentamerus. These inner organs are borne by six partitions in place of a single calcareous loop; the spiral arms are not unrollable.

"Through the separation of these forms (for which the name *Merista* is proposed) from the genus *Terebratula*, an apparent contradiction in the laws of paleontological distribution is solved, since these smooth forms will now be separated, which have heretofore offered an apparent contradiction to the present views of these laws."

Lest I should not have expressed his views rightly in this free translation, I give the original in the note below.†

* This Jour. II, xxxii, 131.

† "Herr Eduard Suess theilte die Erfolge der Untersuchung einiger Brachiopoden aus dem böhmischen Uebergangsgebirge mit, die er gemeinschaftlich mit Herrn Custos Dormitzer in Prag angestellt hatte. Er zeigte, dass mehrere bisher zu den

On page 160 of the same work, there are some farther remarks on the classification of the brachiopoda, by Prof. Suess, in which he refers to the genus *Merista*. No generic description is, however, there given. It appears also that it was again noticed in "Leonhard's Neues Jahrbuch, p. 127, 1854." I have not, at present, access to that work, and do not know whether the genus is described there or not: at all events, at the time Mr. Davidson prepared the English edition of his "General Introduction," *Merista* was not understood.

Prof. King in his "Monograph of the Permian fossils of England" (1850) proposed to restore the genus *Cleiothyris* of Phillips, apparently making it partly equal to *Athyris* McCoy. But the specimen on which this arrangement was founded, was afterward shown to Mr. Davidson, and by him identified with *T. scalprum* Barrande (now *Merista* scalprum), while *Cleiothyris* was intended by its author as a substitute for *Atrypa*. (See Davidson's Introduction, p. 85.)

2. *Subdivision of the Genus by Mr. Davidson in* 1854.—From all the facts above given it may be gleaned that in 1853, when Mr. Davidson was engaged in the preparation of his General Introduction, this group of Brachiopoda was known as a single genus but with two generic names *Athyris* McCoy, 1844; *Spirigera* D'Orbigny, 1847. Each of these was intended by its author to include the whole group. McCoy was under the impression that all the species had the beak imperforate, while D'Orbigny maintained that they were all perforated. Both authors were partly wrong and partly right. The genus was capable of subdivision, but no one had as yet undertaken that task; unless indeed, the observations of Prof. King and Suess can be so construed. With regard to the latter, as the genus *Merista* is now well understood and is different from *Athyris*, it does not affect the question. *Cleiothyris* may be considered as obsolete.

Mr. Davidson in his "General Introduction" in endeavoring to reconcile the conflicting nomenclatures of D'Orbigny and McCoy divided the genus, retaining the name *Athyris* for "forms with an apparently imperforate beak or closed foramen, variously disposed septa and largely developed dental plates." He

Terebrateln gezählte Formen an ihrer Spitze keine Oeffnung für den Anheftungsmuskel besitzen, und dass auch die Vertheilung ihrer inneren Organe auf eine Verwandtschaft mit der ebenfalls nicht angehefteten Gattung Pentamerus hinweist. Diese inneren Organe werden von 6 Wänden, statt von einer einfachen Kalkschleife getragen; die Spiralarme selbst sind nicht aufrollbar."

"Durch das Lostrennen dieser Formen, für welche der Name *Merista* vorgeschlagen wird, von der Gattung, *Terebratula*, wird zugleich ein scheinbarer Widerspruch in den Gesetzen paläontologischer Verbreitung gehoben, da eben jene glatten Arten ausgeschieden werden, welche den bisherigen Ansichten über diese Gesetze am schroffstan entgegengestanden waren."—*Jahrbuch der k. k. geologischen Reichsanstalt, Vienna*, ii, pt. 4, pp. 150, 160. 1851.

selected two species, "*A. tumida* Dal. or *Herculea* Barrande," and specially named them as the types.

He retained *Spirigera* for the group of which *S. concentrica* is the type. As to this latter group, by whatever name it may be hereafter known, its extent will most probably always be that assigned to it in the work in question.

The genus *Athyris*, however, as there defined, included *Merista*, a circumstance which, however, as I shall presently show, in no way vitiates the arrangement. In a note, he states,—"before coming to the above conclusion, I submitted my views to Mr. Deshayes, Mr. Salter, and others, who seemed to consider that this mode of compromising the difficulty could not reasonably be objected to by the two authors principally concerned nor by the generality of Paleontologists." Op. cit., p. 86.

Afterward this classification was strongly objected to by several naturalists, who maintained that McCoy had "originally and positively" applied the name *Athyris* to the *S. concentrica* group, and, therefore, it could not be transferred to the other principal section. He, therefore, in the French edition of this introduction (1856), abandoned his first arrangement,* and substituted *Merista* and *Athyris*, at the same time transferring the latter to *Spirigera*, as in the extract given in the note below. (Op. cit., p. 101.)

Upon a careful examination of all the circumstances I think it will be found that according to the laws of nomenclature this change cannot be sustained. I shall therefore quote some of those laws and endeavor to apply them to this case.

The first rule reads thus:

"S. 1.—The name originally given by the founder of a group or the describer of a species, should be permanently retained, to the exclusion of all subsequent synonyms."

It seems scarcely necessary to quote such a rule as this. I only do so in order to make the comment, that it is the most important of all the laws of nomenclature; and that its operation cannot be prevented in any case, by merely technical objections or by any error in the details of a generic or specific description. Provided the original diagnosis contains sufficient in substance, to enable the scientific public to identify the group, trivial errors, from which the writings of no naturalist are free,

* "Mais ce moyen terme a été critiqué par plusieurs naturalistes qui ont insisté sur ce que le terme *Athyris* avait été originairement et positivement appliqué par son auteur a la *T. concentrica* et sur l'impropriété de l'autre dénomination pour désigner des coquelles telles que les *T. tumida*, *Herculea*, &c. M. Suess nous a informé (2) qu'il avait, en 1851, proposé le nom de *Merista* (3) pour le groupe renferment ces derniers. J'abandonne donc la proposition que j'avais faite en 1853, et je conserve indifféremment l'*Athyris* McCoy, ou le *Spirigera* d'Orb., pour le *T. concentrica*; et *Merista*, Suess, pour les *T. tumida*, *Herculea*, *etc.* (2) *Neues Jahrbuch*, p. 62, janvier, 1854. (3) *Jahrb. k. k. geol. Reichsanstalt*, II, IV, 150, 1851. Mentionné encore dans *Leonhard's neues Jahrbuch*, p. 127, 1854."

will not have any effect. All that can be done is to rectify; not to destroy. One of the exceptions to this rule is thus expressed in No. 11. "A name may be changed when it implies a false proposition which is likely to propagate important errors."

According to this exception if the name *Athyris* should be applied to the *S. concentrica* group there is a possibility of its falling into the list of synonyms; for, although no very important error would be superinduced, yet few naturalists can apply it to shells with a well defined foramen without feeling that such an application is to some extent, inconsistent with the purity of scientific nomenclature.

"§ 3.—A generic name, when once established, should never be cancelled in any subsequent subdivision of the group, but retained in a restricted sense for one of the constituent portions."

"4.—A generic name should always be retained for that portion of the original genus which was considered typical by the author."

This latter rule is preceded by some introductory observations which should be embodied in it as they in fact form a part of the rule itself. They are especially applicable to this case.

"When a genus is subdivided into other genera, the original name should be retained for that portion of it *as at first defined*. Authors frequently indicate this by selecting some one species as a fixed point of reference, which they term the "type of the genus." When they omit doing so, it may still in many cases be justly inferred that the *first* species mentioned on the list, *if found accurately to agree with their definition*, was regarded by them as the type. A specific name, or its synonyms, will also often serve to point out the particular species which by implication must be regarded as the original type of the genus. In such cases we are justified in restoring the name of the old genus to its typical signification, even when later authors have done otherwise."

Now this rule bears directly on the question, because many naturalists are under the impression that the first species placed on the list must *necessarily* be regarded as the type, where the author is silent on that point. But according to the above (and common sense), it is only so if found *accurately to agree with the definition*. *Spirigera concentrica* does not agree either with the name *Athyris*, nor with McCoy's generic description, nor with his typical figure. Therefore it cannot be arbitrarily selected as the type, and the name *Athyris*, in consequence, retained for that group. Indeed in many instances it would be impossible that the first species placed in the genus should be the type, for the author might not have the true type in the collection under investigation.

In this instance, as before mentioned, McCoy was preparing a work exclusively devoted to Carboniferous fossils, among

which *A. tumida* does not occur. In preparing his description of the genus he may, however, have had that species before him, and its imperforate beak may have had some influence.

§ 5. "When the evidence as to the original type is not clear and indisputable, then the person who first subdivides the genus may affix the original name to any portion of it at his discretion, *and no later author has a right to transfer that name to any other part of the original genus.*"

This last paragraph applies as well to the author who first subdivided the genus as to others. Once a genus is established, or subdivided, on sound principles, it becomes the property of science, and the author himself (either of the genus or the subdivision) can make no change. He may amend by striking out the errors, if any there be, but all that is true must remain.

I think that on a careful study of all the circumstances, it will be perceived that Mr. Davidson's first adjustment of this question was the most wise, the best for the interests of science, and the most just toward all the parties concerned, that could be devised. It was not inconsistent with the laws of nomenclature, but in perfect accordance with them in every particular; and, therefore, should be retained.

In one respect, however, it has been modified. *Athyris* as first defined by him, included *Merista* of Prof. Suess. This was, no doubt, due to the fact that the characters of this last named genus were not then accurately known to the scientific public. This makes little difference. *Merista* has long since been separated, with its type *M. Herculea;* leaving the other and most important group for *Athyris* with *A. tumida* for the type.

With regard to *Spirigera*, I think it can also be retained notwithstanding the following rule:—

§ "When two authors define and name the same genus, *both making it exactly of the same extent*, the latter name should be cancelled *in toto*, and not retained in a modified sense."

If the name *Athyris* had been extremely objectionable, according to the 11th rule, *Spirigera* might have cancelled it altogether. But the true principle of interpreting these laws is, that where there is any possibility at all of saving the original name it must be saved, even if the rules be strained to their utmost in that direction. The rules cannot be stretched to destroy; but they may be strongly bent in the other direction, to preserve. If a generic name should be appropriate for a large number of the species of the group to which it was originally applied, and *not very* objectionable as to a few only, I doubt that it can be changed. Such was the case with *Athyris* when D'Orbigny objected to it. More than two-thirds of the species designated by him are imperforate, and he should have retained the name for these. Some naturalists were, therefore, in favor

of rejecting *Spirigera* altogether; others of retaining it. It is not, therefore, a case clearly within the rule; and as there was much doubt, the best course to take, as soon as it was found possible to do so, was taken by Mr. Davidson. He decided in favor of preserving the name.

3. *Authors who have adopted the classification.*—In 1856, Professors H. G. Bronn and F. Roemer, in the third edition of Bronn's *Lethæa Geognostica* adopted Davidson's classification and copied his diagnosis of both genera in full. They cited *A. tumida* as the type of *Athyris*. "Die typische Art ist *Athyris tumida* McCoy. (*Atrypa tumida* Dalman.) Andere Arten sind *A. Herculea* (*Terebratula Herculea* Barrande), *A. pseudo-scalprum* (*Terebratula pseudo-scalprum* Barrande), *A. scalprum* (*Terebratula scalprum* Fred. Roemer)." Op. cit., p. 331.

They also recognized *S. concentrica* as the type of *Spirigera*. "Die typische Art ist *Sp. concentrica* (*Terebratula concentrica* Bronn). Andere Arten sind *Sp. pectinifera* (*Atrypa pectinifera* Sowerby), aus dem Zechstein, *Sp. Roissyi*, (Sp. de Roissyi Levéillé)," &c., Op. cit., p. 332.

In the same year Eichwald placed *A. tumida* in *Athyris* and *S. concentrica* in *Spirigera*.*

In 1860 he also introduced the same classification in his great work on the Paleontology of Russia. The Russian species are *A. tumida*, *didyma*, *ungula*, *cassidea*, *S. concentrica* and *ambigua*.†

In my studies of the Canadian Brachiopoda I had no occasion to describe any species of this group until 1859, when I commenced a series of papers on the Devonian Fossils of Canada West. At that time I had not fully investigated the subject, but understood from a paper published by Mr. Davidson in the "Geologist" (vol. 1, 456), and also from Woodward's "Manual of the Mollusca" (p. 223), that *A. tumida* and *S. concentrica* were thought to be inseparable.‡ Not feeling perfectly satisfied that this was the correct classification, I prefaced my descriptions with the following remarks:—

Genus ATHYRIS,—McCoy.

"There is much difference of opinion as to the propriety of retaining this generic name. It implies that the shells have no foramen in the ventral valve, and yet many are placed in the genus which have the beak distinctly perforated. Some paleontologists are, therefore, in favor of using D'Orbigny's appellation *Spirigera* instead of *Athyris*. Nearly all of the Silurian species, and some of those from the Devonian rocks, have the beak so strongly incurved, that no foramen can be seen. For such, at

* Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands. Bull. Soc. imp. Nat. Moscou, vol. xxix, pp. 419, 422.

† *Lethæa Rossica*, vol. ii, p. 731 (*Athyris*); p. 735 (*Spirigera*).

‡ In this work Mr. Woodward separates *Merista* (although with doubt) as a subgenus, and refers *A. tumida* to *Athyris*.

least, the name *Athyris* does not appear to be very inappropriate. Mr. Davidson still retains it, not only for those which have the foramen concealed, but also for those with it open. It appears probable that the genus will sooner or later be sub-divided, and in that case *Athyris* might be retained for the species with closely incurved beak, and *Spirigera* for some of the others. I shall give some account of the generic characters of this group of shells in another article. The following species are placed in the genus provisionally."—*Canadian Journal*, [2], vol. v, p. 273, May, 1860.

In that paper I described two species with closed beaks, *A. clara* and *A. Maia*, which, no doubt, belong to the genus. The others with perforated beaks, I marked doubtful, thus:—A. (?) *scitula* (Hall); A. (?) *Clusia*, n. sp.; A. (?) *unisulcata* (Conrad); A. (?) *rostrata* (Hall); A. (?) *Chlöe*, n. sp.*

I think it the same as the species called *Meristella Doris* by Prof. Hall (13th Reg. Rep., p. 84, 1860). I doubt that any of the others belong to either *Athyris* or *Spirigera*.

Afterward Prof. Hall (13th Reg. Rep., p. 74) proposed to establish a new genus *Meristella*, precisely identical with *Athyris*, as re-defined by McCoy, in 1852. His diagnosis reads thus:—

"Shells variable in form, oval, ovoid, orbicular or transverse. Valves unequally convex, with or without a median fold and sinus; beak of the ventral valve apparently imperforate, incurved over the beak of the smaller valve; area none; valves articulating by teeth and sockets. Surface smooth, or with fine concentric lines of growth and fine obsolete radiating striæ, which are usually more conspicuous in the exfoliated shell. The interior of the dorsal valve is marked by the presence of the longitudinal septum, and the upper part of the ventral valve by a deep subtriangular muscular impression which unites with the rostral cavity."

Now I hold that instead of proposing a new genus, he should have retained the original name *Athyris;* because his proposition amounts to a subdivision of the group, and according to the laws of nomenclature he should have applied the old name to that portion for which it is most appropriate, as had been done six years before by Davidson. As soon as this new arrangement was published, I re-investigated the subject; and perceiving that it amounted to nothing more than a restoration of Davidson's

* I now think that *A. clara* is the same as Prof. Hall's *Meristella nasuta*; but am not quite sure that it is Conrad's species. *A.* (?) *scitula* was afterward found to belong to a new genus described by me under the name of *Charionella*. (Op. cit., vol. vi, p. 148, March, 1861). It is not *Atrypa scitula* Hall, a point on which I was not certain at the time, as will be seen by the description, which reads thus:—

"The above figures represent different views of two specimens of a species which appears to me to be identical with that figured in the work above cited. It varies greatly in size. The length of the largest specimen that I have seen is seventeen lines, the greatest width fourteen lines, depth eight lines. The smallest is about two lines in length and many of intermediate sizes have been observed to make out the series. It is not certain that this species belongs to the genus *Athyris*." Op. cit., p. 30.

former classification, but with a change of names, I declined to adopt it. In all the publications of our Survey, in which species of this group are described or figured, *Athyris* is used instead of *Meristella*.

On the merits of this classification, a note in this Jour., II, xxxiii, 130, expresses the views advocated herein. The following is an extract therefrom:—

"This is the classification which the writer of the criticism maintains should be sustained, and we cannot see any reasonable objection to it. It is perfectly just toward both McCoy and D'Orbigny. It inflicts no injustice on any other author. It is not inconsistent with purity of zoological nomenclature, or in any way injurious to science. It does not require any modification in either of the original definitions. The typical species are central and dominant forms of two different groups of species which together form one larger general group. *Athyris*, under this arrangement, is the generic name of that group which has *A. tumida* for its type. *Spirigera* is a perfectly unexceptionable name for the other group, of which the typical form is *S. concentrica*. Prof. Hall's proposed genus *Meristella* is precisely identical with the genus *Athyris* in its restricted sense (as above explained), and cannot be admitted until some good reason is shown for setting aside Davidson's arrangement. It belongs to Prof. Hall to place this reason before the public in a clear and unsophisticated manner. If he succeed in maintaining his point, then he will establish a classification for this group of fossils far inferior to that proposed by Davidson. *Spirigera* must be suppressed, and *Athyris* must take its place, and thus stand as the generic appellation of a group of fossils for which it is not appropriate. We hold that this change is not necessary, and as it would, if adopted, be injurious to science by affecting the purity of zoological nomenclature, it cannot be maintained."

ART. VII.—*Experiments on Itacolumite, (Articulite), with the explanation of its flexibility and its relation to the formation of the Diamond;* by CHARLES M. WETHERILL, Ph.D., M.D., Professor of Chemistry in the Lehigh University.

THE rock which derives its name from the mountain Itacolumi in Brazil is certainly one of the most interesting with which we are acquainted. As the companion (probably the matrix) of the diamond, a study of its origin and nature might possibly solve the problem of the formation of that gem; and its flexible character is at such variance with our ordinary experience of the stability of rock, that it is wonderful to those even who are most familiar with it.

According to the authorities, itacolumite is a laminated quartz rock of the talcose series, owing its lamination to a little talc or mica (Dana), to which material its flexibility is also due (Dana,

Percy and others). It occurs in extensive formations in Brazil, the Urals, and in the United States in Georgia, and in North Carolina, and appears particularly to accompany the diamond.

The specimens which I have examined are: 1st. A number of slabs of various size from Saraw Mt., Stokes Co., N. C., given to me by Captain Samuel W. Dewey. 2d. Small fragments of a large slab in the Museum of the Smithsonian Institution, to which it was presented by Charles DeSelding, who obtained it in Rio de Janeiro, its locality being Minas Geraes, the celebrated diamond region of Brazil. These two specimens have the same general appearance; with the exception of color, which for the North Carolina rock is a light yellow, and for the Brazilian mineral a light reddish brown, and of the granular condition, which is finer for the North Carolina specimen.

They may be split more readily in one direction yielding slabs, and there are occasionally small fissures at right angles to these layers. There is also in one of my specimens a plane forming an angle of 15° with the plane of readiest cleavage and perpendicular to the planes of the fissures. It appears to be a joint and is covered with small crystals of quartz.

Scattered through the rock are small scales of mica which are comparatively few in number but of uniform size, thin, and determine the cleavage of the rock. These plates lie in parallel planes, as they would settle naturally from a liquid. Where they are abundant in any plane the rock splits there readily. If a piece of the itacolumite, thus split, be rubbed down perpendicularly to the cleavage plane, no scales of mica are perceived upon this new surface, because the observer is looking at the edges of the micaceous plates, but the lamellar nature of the rock is thus made very apparent.

The chief constituent of the rock under the microscope is quartz in very sharply fractured and fine grains, together with a little mica. Occasionally are to be seen very minute black grains. One specimen when rubbed down shows small pieces of compact white quartz, giving it the appearance of a section of sausage. The specific gravity of the North Carolina specimen, taken in the ordinary manner, is 2·61; but 2·69 after freeing its pores from air by a vacuum [sp. gr. of quartz 2·65]. The analysis yields the following results:

Vol. at red heat (water),	0·17
Silica,	95·89
Sesquioxyd iron,	2·78
Lime,	0·84
	99·68

Besides which, the qualitative analysis yielded traces of KO, NaO, MnO, MgO; but no Al_2O_3. The ferric oxyd, obtained

also by attacking another portion of mineral by hydrofluoric acid, was 2·03 p. c. The iron is not distributed very uniformly through the rock, as may be readily seen by an inspection of specimens.

I found it impossible to separate completely the mica from the quartz by edulcoration. When the result of the washing is examined with the microscope, scales of mica are seen, generally colorless, but sometimes dark brown, and all polarizing light, as do also the grains of quartz.

This fine edulcorate when heated on platinum foil B.B. cakes together slightly, and a slight dust adhering to the platinum does not fairly melt but exhibits signs of intumescence. With salt of phosphorus very fine grains of silica are seen floating in the bead. With borax a clear glass without intumescence results. An experiment for HFl with the itacolumite mica yielding negative results.

The mica examined with the spectroscope gave the reactions of KO and NaO only. No different result was obtained after the mineral had been attacked by liquid hydrofluoric acid, and the residue evaporated to dryness with sulphuric acid before exposure to the flame.

The relative hardness of the siliceous grains in the mineral appears to be that of agate which may be scratched slightly by them. On one occasion the bottom of an agate mortar received a very decided scratch which gave color to the supposition of a minute diamond as the cause. The rock is quite porous when compared with other sandstones; water placed in an excavation will filter very readily through the stone, even in a direction perpendicular to the plane of stratification. Gases diffuse very easily through these pores; if a slab of the itacolumite one quarter of an inch in thickness, be cemented to the top of a glass cylinder, which is then filled with hydrogen, water rises very rapidly into the tube.

When the mineral is raised to a red heat, it acquires a red color when cool; when plunged hot into water it does not become more friable. Under the HO flame it fuses to a nearly colorless glass. Heating to redness does not impair the flexibility of the stone.

The specimen from Brazil was not analyzed. It presented the same physical character as the North Carolina mineral. Its color was different, being reddish brown.

In the Brazil sandstone, the siliceous grains are larger. To the eye the quantitative relation of the silica to the mica is the same for both specimens; if there be any difference, it is in favor of a somewhat larger proportion of *mica* in the Brazilian itacolumites.

Explanation of the flexibility.—The flexibility of this rock is attributed universally to the mica which it contains, an inference which the microscope shows to be unwarranted. This flexibility is due to *small and innumerable ball and socket joints,* which exist throughout the mass of the stone very uniformly. Each joint permits a slight movement which is always greater in one direction. The accumulation of joints suffers a limited motion in every direction. This mobility is not perceptible in thick slabs unless they are large as to their other two dimensions. From such a slab it is easy to obtain a small and thin piece in which the flexibility may be observed; and the thinner the section the greater is the motion. Where small joints or fissures occur, the motion is greater at those points.

This jointed structure is so wonderful that it would warrant the name "articulite" to be given to the mineral, especially if we should find it again in other sandstones by observing them in very thin slabs.

To determine the nature of the motion, at first, various thin sections of the stone were taken, cut in three directions, viz: one parallel to the plane of stratification, one perpendicular to this plane, and one perpendicular to each of the above planes.

The sections were made by cementing layers of the rock upon a glass slide with shellac, rubbing down to the required thinness upon a slab of the itacolumite, and removing the resin by alcohol.

These sections were fastened to a piece of cork in such a manner that they might be moved, and the motion observed under the microscope. The sections behaved alike and the play of the joints was at once seen. I subsequently found that thin sections were not at all needed for this purpose, since the articulations may be perceived with the microscope in any fragment of the mineral. A piece is fastened to the stage, which is then inverted and slightly tapped to remove any loose grains of sand. Upon adjusting the instrument and touching the specimen gently with a quill point, it is perceived to be composed of small botrioidal masses or congeries of grains of sand. The observer can scarcely divest himself of the impression that he sees a loose layer of sand, until the stage is again inverted and jarred, which demonstrates that the grains are interlocked. By managing the reflected light, with which the object is illuminated, the plates of mica can be distinctly seen; they are very few in number and *take no part whatever in determining the motion.* The articulation is *not* that of basaltic columns. The component grains are arranged so that most of the groups have cavities and projections, and so that the projection of one group engages in the cavity of its neighbor.

By observing the thin edge of the specimen regular cavities

are seen, out of which groups of sand particles have fallen. The rock may even be dissected by the needle point and shown to be made up of such congeries, and the groups may also be resolved into their constituent grains.

The millimetric length and breadth of the groups varies from $0{\cdot}26\times0{\cdot}26$ to $0{\cdot}26\times0{\cdot}32$, and the size of the individual grains composing the groups averages between $(0{\cdot}026)^2$ to $(0{\cdot}04)^2$ mm. Many are as large as $(0{\cdot}08)^2$ and some as small as $(0{\cdot}013)^2$. The general cubic capacity of a group or grain could be determined by multiplying the above areas by one of the linear dimensions given.

Each group appears to be composed of from 20 to 50 grains of sand not very strongly agglutinated. The individual grains are very "sharp" fragments of silica, not flat plates, and of great uniformity with respect to size.

The scales of mica are flat and nearly square fragments. They average in area $(0{\cdot}08)^2$ mm. and vary from $(0{\cdot}26)^2$ to $(0{\cdot}065)^2$ mm.

The Brazil mineral presents almost exactly the same character under the microscope as that from North Carolina, with the exception that the individual grains, as well as the congeries, are somewhat larger in the former. The oxyd of iron in the mineral is not the *cement* by which the grains are united, for a thin section of the rock boiled in HCl for five hours did not become more friable. The cement would appear rather to be siliceous (hydrated silica); because a piece boiled in a solution of caustic soda becomes partially disintegrated, especially at the edges, and is much more friable as to its mass.

When dilute solution of hydrofluoric acid is poured upon a thin section it is immediately resolved into grains, affording a complete disintegration of the section.

The flexibility of the itacolumite (N. C.) is shown in a striking manner with a cylindrical piece sawed out from a thick slab of the sandstone and rubbed down upon another piece to the required shape. The planes of stratification were taken parallel with the cylinder's axis.

The specimen measures 198 mm. ($7\frac{3}{4}$ in.) by 13 mm. ($\frac{1}{2}$ in.) in diameter. It can be compressed and elongated in the direction of its axis, the extent of the motion being a little over $\frac{1}{2}$ mm. When one end is fixed, the other end may describe a circle of 34 mm. ($1\frac{3}{8}$ in.) diameter, and may be made to touch every point in the area of the approximate spherical zone. The rod can also be twisted about its axis, the torsion being 10°.

Catenary.—When the rod is supported upon two nails 185 mm. apart, it assumes the form of a curve very like the catenary. The greatest deflection from the line joining the points of support varies from 3 to $3\frac{1}{2}$ mm. as the rod is rotated about its axis

on the nails. My colleague and Prof. of Mathematics in the University, Col. E. W. Morgan, very kindly undertook the discussion of this curve with the following results. The curve was traced upon paper with a pencil under the stone resting upon two points of support at its extremities and the ordinates were measured for comparison with the ordinates of different curves.

Prof. Morgan at first compared with the circle, as the curvature was so slight, but it departed sensibly from that curve in such a manner as a true catenary would do. He then compared it with a loaded catenary (which is a parabola) with similar results. The beam loaded with equidistant equal weights (ellipse) was next essayed but the curve did not agree with it. Nor did it coincide with the true catenary. It was nearer to the loaded catenary than to any known curve. The result therefore of the calculation indicated that the curve of the stone lay between the catenary and the ellipse.

Prof. Morgan next prepared an experiment with a small beam of white pine loaded with equal equidistant weights for the ellipse, with a fine and flexible gold chain for the catenary, and with the stone cylinder. These were placed upon the same supports (185 mm. apart) and so arranged that the greatest deflection for each curve should be to the same point.

Upon comparing the chain with the loaded beam it was evident that the latter curve was a true ellipse, and consequently the comparison would be attended with no uncertainty due to a supposed defect in the slip of pine. The chain and stone were compared next, and then the stone and beam. Although the experiment was not of a character to afford very delicate measurements, it showed with great clearness that the curve of the stone is very nearly a catenary, and that it lies between this curve and the ellipse.

This result which was not anticipated by either of us, for we expected that the curve would prove to be a catenary, is very interesting and agrees with the jointed condition of the stone, as well as with the character of the joints shown by the microscope.

In a flexed beam the forces are partly compressive and partly tensile, as we consider the upper or the lower portions of the beam, and when the beam is loaded with equidistant equal weights, the conflict of these forces causes the beam to assume the form of the ellipse. The itacolumite cylinder takes the catenary form by reason of its ball and socket joints. But the rod has a definite thickness and a *series* of joints parallel with its axis, in this respect unlike a true chain. Furthermore, as the microscope shows, the sockets are *rough*, as they are formed by grains of sand, and the protuberances fitting into them are also rough. Consequently, when the stone bends by its weight between the

supports there is a compressive action toward the top, and a tensile one along the bottom of the cylinder, as in the case of a beam, and this gives an elliptical character to the curve. As the diameter of the rod increased or diminished, I should expect to find the curve of the stone approach the ellipse or the true catenary.

The relation of itacolumite to the diamond.—The most interesting relation of this rock is to the diamond which it accompanies. This gem, found at first in the "gurgulho" or disintegrated rock, has at length been discovered *in situ* in the itacolumite itself; thus showing that this sandstone is at least one of the sources of the diamond.

The physical conditions which have led to the peculiar jointed character of the itacolumite may have had an important bearing upon the crystallization of the diamond, and hence it is of interest to ascertain what those conditions were, with the hope of throwing light upon the origin of the gem.

I confess to be at a loss to offer a very reasonable hypothesis with respect to these conditions. It is difficult to see why the siliceous fragments cohere to form definite groups or congeries. If we suppose that planes having a certain relation to the crystalline axes cohere by long continued contact more readily than planes having a different relation, why does this partial cohesion occur with such surprising regularity; why also is it not perceived in other sandstones? It would appear that the sand which formed this rock contained something diffused in a regular manner (and which was subsequently removed), which prevented the uniform contact of the siliceous grains. It is possible to conceive that *petroleum* might have that effect when added to sand of a certain degree of moistness, forming a kind of emulsion, and that the petroleum was afterward slowly removed by a process which permitted a crystallization of a portion of its carbon. When water was dropped upon dry sand, the mixture when stirred, formed lumps of uniform size; if, before stirring, a little petroleum was added, the lumps appeared to form more readily. The lumps are left out of aqueous contact by the coating of petroleum around each one, while the siliceous particles forming the lumps have water between their component grains. Cohesion could take place between the particles, but not between the lumps. Under the microscope the sand thus treated bears a striking resemblance to itacolumite.

I made this supposition before acquaintance with DeChancourtois's hypothesis that the diamond may have been formed from hydrocarbons, and that its origin is thus connected with the existence of petroleum-bearing schists. My hypothesis therefore receives a certain support from the views of DeChancourtois.

I have heated several of my specimens of itacolumite to ascertain whether any petroleum odor was evolved, but with negative results. If the diamond proceeded from a slow and gradual oxydation of the hydrocarbon perhaps we should not expect to find any petroleum left.

In this connection the small and rarely occurring black specks, seen with the microscope, are to be noted; are they minute black diamonds, and have they any relation to the experiment where the agate mortar was so deeply scratched?

Bethlehem, Pennsylvania, April 6.

ART. VIII.—*On the Laws which govern the general distribution of Heat over the Earth;* and on Brewster's Neutral Point;* by PLINY EARLE CHASE.

1. *The laws which govern the distribution of heat.*

THE principal elements of general thermometric variation are: 1, the heat imparted by the sun; 2, terrestrial absorption and radiation; 3, atmospheric currents. Of these three agencies, the first is, in one sense at least, the chief, since it is the one on which the others depend; the second is mainly instrumental in modifying the other two, and especially in retarding the daily and yearly changes; the third is a subject of hourly experience, and its meteorological importance is now generally recognized.

The amount of heat which is received directly from the sun, evidently varies as the cosine of the zenith distance, or the sine of the sun's altitude. In the daily distribution of temperature this is the most important element, as is evident from the tabular comparisons in my communication of Sept. 21, 1866.† Absorption and radiation proceed at nearly uniform rates, therefore it may be assumed that their effects are approximately proportional to the time during which they operate. The average general variation which is due to the influence of the winds is a difficult point to determine, but the present investigation has led me to believe that it may be measured by the difference of *arc* (instead of the *sine*-difference) of the sun's meridian altitude. My reasons for this inference are the following: 1, the general average temperature of the year often appears to vary very nearly as the arc in question; 2, it seems unreasonable to suppose that a variation of this character can be attributable either to the heat communicated by the sun or to terrestrial absorption and radiation; 3, the tendency of the air, so far as it is deter-

* Abridged from the Proceedings of the Am. Philosophical Society, Feb. 1, 1867.

† Proc. Amer. Phil. Soc., vol. x, pp. 261–269. See, especially, the observations at St. Bernard, and the general average of Table I, p. 267.

mined by the direct heat of the sun, is at all times toward that point of the earth's surface at which the sun is vertical, and we may readily believe that that tendency should be proportional to the distance, measured on a great circle of the earth, through which the air would be obliged to move in order to reach the sub-solar point. This distance evidently varies as the *arc* of the sun's zenith-distance.

We have, then, three natural standards for admeasurement, by means of which, if we rightly eliminate special and limited perturbations, we may perhaps be able to determine the predominating influence, in many cases both of local and of general thermal disturbance. In order to institute as broad a comparison as possible, I have adopted a method of elimination which may be illustrated by a single example.

The average monthly temperatures of the United States, as deduced from Prof. Coffin's reductions, appear to be as follows:

Jan. 28·352	Feb. 30·873	Mar. 39·049	Apr. 49·744	May 60·902	June 69·780
July 75·640	Aug. 71·754	Sept. 65·643	Oct. 53·922	Nov. 42·350	Dec. 32·132

Averaging the temperature at equal intervals from January (taking the mean temperature of Dec. and Feb., of Nov. and March, &c.), we get the following results.

Months from Jan.	0	1	2	3	4	5	6
Average temp.	28·352	31·502	40·699	51·833	63·272	70·767	75·640
Monthly diff.	....	3·150	12·347	23·481	34·920	42·425	47·288
Ratio of do.	....	·067	·261	·497	·738	·897	1·000
Ratio of diff. of zenith distance,	....	·069	·255	·500	·745	·931	1·000

The second of the above series of ratios (that of the differences in the arcs of the sun's zenith-distance) is based upon the following estimate of the average monthly increase of solar altitude at all places in the temperate zones.

Mos. from winter solstice,	1	2	3	4	5	6
Increase of solar altitude,	3½°	12°	23½°	35°	43¼°	47°
Ratio of increase,	·069	·255	·500	·745	·931	1·000

If we allow about 24 days for the cumulative effects of increasing heat and cold, these ratios become properly comparable with the monthly ratios of temperature-variation, as in the following table, which is compiled from the works of Dove and Guyot.

Diff. of time, mos.	1	2	3	4	5	6
Ratios of sines,	·076	·284	·545	·784	·946	1·
" " arcs,	·069	·255	·500	·745	·931	1·
N. Hemisphere,	·076	·259	·512	·753	·935	1·
S. Hemisphere,	·077	·281	·538	·763	·938	1·
Arctic region,	·071	·231	·479	·733	·934	1·
Europe,	·069	·239	·501	·738	·938	1·
Asia,	·097	·274	·535	·769	·934	1·
N. America,	·055	·279	·494	·741	·917	1·
S. America,	·077	·275	·501	·724	·936	1·
Africa,	·088	·267	·537	·761	·938	1·
Australia,	·081	·313	·618	·801	·913	1·

An extensive series of comparisons* seems to warrant the following inferences, all of which are confirmed by other considerations.

1. Taking into view the entire land surface of the globe and the entire range of the year, the direct heat of the sun and the induced aerial currents appear to be about equally instrumental in determining fluctuations of temperature.

2. The influence of the winds is most marked in the Northern and Western hemispheres; that of solar obliquity, in the Southern and Eastern hemispheres.

3. Where the sun's rays are least intense (as in the Polar Regions) and where the winds are most variable, the ratios exhibit the nearest parallelism to the increments of arc; but where the winds are most uniform (in and near the region of monsoons), they correspond more closely with the sinal increments.

4. The general changes of temperature at midwinter, and at the equinoctial seasons (when the sun's declination is changing most rapidly), are most dependent upon the local solar heat; the midsummer changes are more subject to the influence of the winds.

5. The greatest conflict of opposing forces occurs during the sun's passage between the comparatively wind-governed Northern hemisphere and the sun-governed Southern hemisphere. This conflict is manifested in the spring and autumn rains.

6. The closest and most general approximation of ratios is shown in the monthly temperature change at midsummer, which corresponds almost precisely with the change of arc.

2. *On Brewster's Neutral Point.*

In the April number of the Philosophical Magazine, Sir David Brewster says: "Dr. Rubenson has never been able to see, even under the fine sky of Italy, the neutral point which I discovered under the sun, and which, I believe, has never been seen by any other observer than Mr. Babinet."

The point is question can be easily seen in Philadelphia on any clear day, when the sun is more than 20° above the horizon, and I have reason to believe that it can be found with equal ease at many other places in the United States, although I have not been able to find any published observations except my own.†

As all the phenomena of skylight polarization are very interesting, and as some of its laws are still imperfectly understood, others may, perhaps, be induced to turn their attention in this direction, so as to determine whether the difficulty experienced by European observers is owing to a higher latitude, to a moister atmosphere, or to some other cause.

* See Proceedings, &c., loc. cit.

† Proc. Amer. Phil. Soc., vol. x; this Journal, vol. xlii, pp. 111, 112.

A simple Savart polariscope is sufficient for making the observations. In positing Brewster's neutral point, I have usually raised the lower sash of an attic window so that the bottom of the sash will screen the sun from the polariscope. I have thus been able, in every instance when the atmospheric conditions seemed favorable, to see very distinctly the neutral point, and the oppositely polarized bands above and below.

ART. IX.—*Contributions toward a Theory of Photo-chemistry;* by M. CAREY LEA.

IN a somewhat extended series of experiments published at various times,* I endeavored to fix, as far as I was able, some of the facts of photo-chemistry, and more especially the nature of the action of light upon iodid of silver, at once the most important and the most difficult of explanation of all the facts of photo-chemistry which fall under our notice. The phenomena exhibited by iodid of silver, in the point of view which they assume to me, are the key to the whole matter, and based upon them, I propose to offer some theoretical views upon the general subject.

The study of light has always been largely aided by analogical reasoning from another source—that of sound, whose phenomena probably afforded the first conception of the undulatory theory, and in turn, discoveries made in light have aided our knowledge of the phenomena of heat, many of which would perhaps have been still unknown but for the aid so obtained. It is therefore perfectly allowable to reason analogically back from heat to light.

The tendency of heat is always to equalize itself, by radiation and conduction. The loss of heat in this way where the body affected is much above the temperature of those that surround it is enormously rapid, and this loss continues with diminishing rapidity till an equilibrium is attained.

The same is the case with light, though the loss is there usually so much more rapid as to be almost simultaneous with the reception, to our senses, and in the ordinary conditions of observation it is quite so. But the exceptions are perfectly well marked. The phenomena of *phosphorescence* show that a body may retain the impression of light for a considerable time. And the phenomena of phosphorescence received an immense extension from the ingenious and beautiful experiments of Becquerel,

* A brief résumé of many of these experiments was published in this Journal in the year 1866.

who showed that a very large number of bodies continued to emit light for an appreciable time after the direct influence of light ceased to operate upon them. Although the time might be but a very small fraction of a second, still it was rendered brilliantly evident to the sense, and the exact period could be measured. And when we consider the enormous rapidity with which the phenomena of light take place, even the fraction of a second is a long time, and it would be exceedingly rash to attempt to limit such phenomena to our powers of observation.

Just as with heat there exists in all probability an absolute zero at which heat-vibrations cease, so probably there is a light zero at which the body ceases to vibrate luminously. Most bodies (to our perception) reach this zero immediately when carried into darkness. Phosphorescent bodies, form, however, a striking exception.

Let us suppose that a body be surrounded by other bodies equally illuminated, and that temporarily an additional quantity of light falls upon it. On the cessation of this illumination, the body will recover its condition of equilibrium with surrounding bodies, by losing its excess of light in the following manner: 1. By reflection. 2. By transmission. 3. By conversion into heat. 4. By chemical action. 5. By radiation.

That is, the body, if it be transparent, or have reflecting surfaces, will part with a certain quantity of its light in those ways. If it is susceptible of chemical decomposition, a certain portion of light will be consumed in effecting that decomposition. And what farther loss is necessary to take place in order to reach an equilibrium, must take place by conversion into heat and by radiation. As we have already seen, this radiation may be either instantaneous, as in the case of most bodies, or it may require minutes, hours, or even days, as in the case of phosphorescent bodies. This fact is of the utmost importance in the attempt I here make to explain the phenomena of photo-chemistry.

In their influence upon combustion and decomposition, the phenomena of light and heat exhibit a striking parallelism. Each tends in some cases, to promote combination, but in the vast majority of cases, to dissociate elements already combined. Such especially is the action of light in the cases which I propose to consider.

I have shown elsewhere, that, contrary to long-established opinion, perfectly pure iodid of silver, isolated from all other substances, is sensitive to light, and this fact, now I believe universally admitted, must form the corner-stone of photo-chemistry. For iodid of silver is precisely the only substance fitted to give us a clear view into the action of light upon matter in general, by which I mean that this action is so much more evi-

dent and appreciable in the case of iodid of silver, that we may thence obtain views subsequently to receive a wide extension.

Now when pure iodid of silver is exposed to light, it changes slightly in color, and has acquired a new property, that of attracting to itself a metallic precipitate in the act of forming, or a metallic vapor already formed. Some have seen in this action of light upon the iodid, a distinct reduction to sub-iodid. But of this, proof is altogether wanting. An extension of the exposure many million fold does not produce a reduction appreciable by the most delicate reagents, and I have been enabled to prove that such iodid perfectly recovers its sensibility in the dark. That is, a film of such iodid, exposed for many hours to a bright sun does not further darken beyond the change produced by the first instants of diffuse light. And if then put aside in the dark for a brief time it re-acquires the capacity by exposure for a second, to receive an image.

But if, during this exposure, or subsequent to it, a body capable of combining with iodine be brought into contact with it, a true chemical decomposition takes place. The silver loses half of its iodine, is reduced to sub-iodid, and a vapor, or a precipitate, under favorable circumstances, is attracted to the parts so acted upon.

What then is the nature of this change, this impression, received in a second, and then slowly passing spontaneously away? Evidently a physical, not a chemical change, though leading the way to a chemical change. But what is that physical change?

When light falls upon a compound body, its molecules are made to vibrate, and if that vibration be carried to a certain violence, the excursions of its atoms may exceed the limit which their affinity permits, and the compound will be torn asunder. We have an exact analogue of this in sound. A thin glass vessel, if a certain note be sounded near it with sufficient force, will be shattered, the excursion of its atoms exceeding the limits imposed by its attraction of cohesion. Vessels of other materials would resist this and much greater strain. Just so with light. Some bodies will be decomposed, others will resist. So when pure *chlorid of silver* is exposed to the light, it presently assumes a violet color, losing at the same time one-half of its chlorine. On the other hand, when pure *iodid of silver* isolated, is exposed to light, no chemical change takes place. But the impression of light is for a time persistent. Now the analogy which exists between this effect and phosphorescence has not been before perceived. *The "physical" impression of light is a persistence of the invisible (or "chemical") rays exactly parallel to the persistence of visible or luminous rays, in phosphorescence.* The vibrations excited by light are in both cases not given out instantaneously

as in most light-phenomena that pass under our notice, where the return to photo-equilibrium is immediate, but this equilibrium is only reached after the interval of hours or days.

Consequently, so long as these vibrations of non-luminous light (so to speak) continue, the body under their influence is much more exposed to suffer decomposition than when under normal influences. And if a film of such material has had parts exposed to light while other parts have been protected, and the whole be then exposed to influences provocative of decomposition, it is evident that those influences may be so graduated that they will tell only upon the parts predisposed by the impression they have received.

This function of light which I here endeavor to prove the existence of, may be conveniently termed *Actinescence.*

That this word does not express with entire accuracy what is intended to be conveyed, is sufficiently evident. But it has the advantage of connecting the phenomena with the parallel one of phosphorescence, and is perhaps on the whole as well suited as any other that could be found or made.

Where, through phosphorescence, a body temporarily retains, and subsequently emits light, that emission, in the gradual return to its photo-equilibrium, is rendered evident by the phenomena that usually accompany the emission of light. Surrounding objects are illuminated, faintly but visibly. Should we not therefore expect similar results in the case of actinescence?

Not only should we find them, but they have actually been described, though not understood. For in actinescence we have the explanation of the phenomena described by Niepce de St. Victor as the "storing up of light" (emmagasinement de la lumière). St. Victor showed that certain objects exposed to light and then carried into darkness had in some cases acquired the power of acting chemically upon other bodies with which they were placed in contact. His results were received at first with something like derision, and the facts, which could not be denied, were said to arise from some chemical decomposition which had taken place in the body during its exposure to light, generating reducing agents which were subsequently given off in the darkness.

But until now, the identity between the latent physical image and the storing up of light has not even been guessed at, still less the perfect parallelism between these phenomena and that of phosphorescence. That a body may immediately regain its equilibrium with respect to one sort of rays and slowly with respect to another, involves no difficulty whatever; we continually see this in the facts of common phosphorescence. Differ-

ent phosphorescent bodies emit light of different colors. If one phosphorescent body emits a red, another a green, another a blue light, there is evidently no difficulty in conceiving that in others, the tendency to a slow recovery of equilibrium may belong to the still more refrangible and invisible rays of the spectrum. In fact this is so completely within the analogy of the subject that it would be surprising if it were not the case.

Viewed in this manner, the physical impression of light, as distinguished from the chemical, loses all its difficulty and mystery. A substance like iodid of silver is capable of decomposition by light, only when in contact with some substance having an affinity for iodine. But if exposed in an isolated condition, it becomes *actinescent*, it retains the disturbance occasioned by the light, and only gradually parts with that energy to surrounding objects. So long as any portion of this impression lasts, it is capable of undergoing decomposition if brought into contact with substances capable of taking up iodine from it.

Iodid of silver when exposed to light in a state of perfect purity and isolated from all other substances, undergoes no chemical change. Carried into darkness, it continues to vibrate in unison with the more highly refrangible rays, either those entirely beyond the visible spectrum, or else those having a very low illuminating power, and this in so faint a degree that no phosphorescence is visible. If it now be brought into contact with any substance which would have occasioned decomposition in presence of light, then, so long as this phosphorescence of actinic rays, this *actinescence* continues, the same decomposition will take place. If simply left in darkness, this actinescence will, as I have already shown, gradually expend itself, precisely like ordinary phosphorescence. And also as in the case of ordinary phosphorescence, a fresh exposure to light will create a fresh impression, the iodid of silver having apparently perfectly recovered its original condition. With perfectly pure iodid of silver, twenty-four hours is sufficient to nearly obliterate the action of light, the actinescent power is exhausted, or nearly so, and the iodid can be exposed again. If this second exposure be made under a photographic negative, and an ordinary photographic developer is applied, a clear sharp image is obtained.

It seems worthy of remark that though no visible phosphorescence is noticeable in the case of iodid of silver, it is by no means impossible that if examined by the ingenious instrument constructed for Mr. Becquerel by Mr. Dubosc, a visible phosphorescence might also be observed. However this may be, it does not affect the principles here laid down.

The general views here expressed will be found to throw light upon other obscure photo-chemical phenomena besides the latent physical image. Of these I shall briefly cite one.

If light fall upon a body decomposable by light, its energy will be expended in two directions. Part will be transmitted to surrounding objects, part will be expended in dissociating one or more of the elements of the body. As the intensity of the light increases, the amplitude of the excursions also increases, and a larger proportion will be expended in decomposition. It therefore follows that the decomposition effected will not be in the ratio of the intensity of the light, but will be greater in a strong light and less in a weak; that is, that a light of half strength acting for a double time, will not effect an equal amount of decomposition. Now this exactly accords with the universal experience of photographers who find that where media of unequal thickness are interposed between a sensitive surface and the light, as in the case of a negative superimposed upon chlorid of silver, the weaker the light the greater will be the contrast in the degrees of effect produced upon the different parts of the film; so much so that this is systematically adopted as a base of operation.

To enlarge farther here on the application of these principles, and the light they throw upon photographic phenomena, would, however, be inconsistent with the limits I have imposed upon myself. My object here has been to prove the existence of a well-marked but hitherto overlooked property of matter, and further to show the identity of this property with what in photo-chemistry has been vaguely described as the physical image.

This explanation of these obscure phenomena seems so simple and sufficient as scarcely to require proof. Nevertheless that proof is afforded by the reactions of iodid of silver, perhaps the most remarkable substance with which chemistry makes us acquainted. This theory rests upon two properties for whose existence I have long contended, and which I believe I have succeeded in establishing, namely, the *sensitiveness to light of iodid of silver even when perfectly isolated*, and its *spontaneous recovery of that sensitiveness* after obliteration through powerful action of light, by simply remaining in darkness. From these facts I deduce the conclusion that the latent image is simply due to a phosphorescence of chemical or actinic rays to which property I give the name of actinescence.

ART. IX.—*Contribution to the Chemistry of Brines;* by CHARLES A. GOESSMANN, Ph.D.

ALL natural solutions of chlorid of sodium, which are used for the manufacture of salt, are more or less contaminated by various saline admixtures. The peculiar influence exerted by certain of these foreign compounds on the chemical composition, the form, and the general external appearance of the chlorid of sodium, during its separation as a commercial article, even under the same system of manufacture and with the same precautions, has occupied the attention of chemists from the earliest times in the history of this branch of chemical industry.

A classification of brines, for the purpose of aiding their investigation, had in the course of events become advisable; and among others, Karsten* at an early date, made some advances in this direction. In his valuable discussions upon brines he has adopted the following principle; the brines are divided into two classes; the *first* class includes all brines containing *chlorid of magnesium* and *sulphates;* and the *second* class those containing *chlorid of calcium* beside *chlorid of magnesium.*

He favored at that time, the volcanic theory, in regard to the origin of the rock salt (primitive deposits), a view long since discarded as a general rule, in favor of its marine origin. He considered it self-evident, that the brines, in every well investigated case could be proved to originate from the dissolving action of an underground fresh water current upon rock salt. Their differences in composition were ascribed,—leaving the concentration as to amount of salt dissolved entirely out of the question,—in regard both to quantity and to quality, to the peculiar nature and condition of the strata, which had intercepted their passage to the surface. According to his view, decaying pyrites, sulphates and chlorids of the metals and earths were the main cause of the contamination of these solutions of rock salt. The extent to which these compounds happened to be met with, decided ultimately the amount of foreign admixtures thus imparted, while their final quality and relative proportion was determined by the order of succession in which the contaminated brines chanced to traverse limestone rocks or dolomites. The gypsum present was considered in most cases to be the result of the reaction of soluble sulphates—particularly of the alkalies, of magnesia or of iron, upon chlorid of calcium; moreover, primary and secondary deposits of chlorid of sodium were admitted. The presence of chlorid of calcium consequently was looked upon as merely accidental, no certain relation as to its connection with a particular geological age, being presumed. Subsequent

* C. J. Karsten, Salinenkunde, vol. i, p. 220. Berlin, 1847.

investigations gave more importance to the presence or absence of this compound; and its presence has since been recognized as especially characteristic of the salt deposits of ante-tertiary date. Consequently these have been considered as a product of the constant admixture of the oceanic waters of preceding geological periods; while on the other hand its absence in our present ocean and in most salt deposits of a more recent date, is an established fact. Although the results obtained by numerous investigations are such as scarcely to admit of a doubt, that changes in regard to the chemical composition of the oceanic waters have taken place in the course of time, and are still in progress, we must acknowledge, that our ideas concerning the main features of the primitive or silurian oceans are still vague, and especially so upon this one point.

As mineral waters and brines issuing from Silurian rocks are at present the only sources from which we can draw information, our conclusions must partake of a more or less arbitrary character; for both these saline solutions may be due to a percolation of fresh water through Silurian rocks impregnated with the *entire* saline matter of the concentrated or evaporated marine waters of a preceding, a contemporary, or a succeeding geological period; or, they may be due to a re-solution of portions of such deposits, or to a mere oozing out of their mother-liquors in in a more or less diluted condition. The difficulties in establishing even approximately their original composition are increased when we contemplate the possible changes which the original saline mass may have suffered in the course of time* in consequence of mechanical and chemical influences and subsequent alterations of its partial solutions in passing to the surface. Yet as long as the discovery of a well preserved marine evaporation of undeniable Silurian origin does not furnish us with a fitter material to study, we have to make the best of the means at hand; for it cannot be denied, that much interesting and useful information bearing upon general principles in chemistry and geology has been and may hereafter be drawn from the study of the saline solutions, mineral waters and brines of decided Silurian origin, i. e., issuing from Silurian rocks. The Silurian rocks of the State of New York abound with saline springs and mineral waters of various kinds;† the same fact is known in Canada. T. S. Hunt has recently illustrated‡ by analytical statements, the relation which various kinds of mineral waters, mainly from Canada, bear toward each other; his arguments tend to prove, that the various classes of Canadian waters

* An examination of the rock salt deposit at Stassfurt, Germany, shows that the whole deposit suffered at a later date from influences which, among other results, caused the formation of Tachhydrite (=CaCl+2MgCl+12HO—Rammelsberg, etc.) —F. Bischof, Steinsalzwerke bei Stassfurt. Berlin, 1864, pp. 33-34.

† See Geology of State of New York, etc.

‡ This Journal, March, July, September, 1865.

referred to in his essay can be considered as originating from one and the same primal source; and that they have changed in consequence of the peculiar kind and condition of the rocks with which they came in contact. The changes themselves appear to be more considerable where disturbances and molecular changes within the sedimentary rocks have favored disintegration.

The main reaction upon these saline waters is ascribed to alkaline solutions, resulting from decaying feldspathic rocks, soluble silicates and particularly carbonate of soda.* The differences which are observable in these waters in regard to the relative proportions of chlorid of sodium and the admixtures of alkaline earths whilst passing through the various stages of alteration, are explained by the fact, that the alkaline earths, lime and magnesia, are gradually rendered less soluble and thus partly eliminated as sediments in consequence of the change from chlorids and sulphates into carbonates and silicates, and that finally the eliminated chlorid of calcium, and magnesium, reappear as an increased amount of chlorid of sodium.

In a previous publication† I described a series of experiments which had been instituted for the purpose of supporting the view entertained by myself in regard to the chemical composition of a certain class of mineral waters of Onondaga Co., N. Y., and their relations to the brines of Syracuse in particular. In the course of that discussion I stated that a sufficient amount of carbonate of magnesia added to these brines, displaced quite readily the chlorid of calcium by forming chlorid of magnesium and carbonate of lime, and produced finally, at the expense of the sulphate of lime, if exceeding the chlorid of calcium in chemical equivalents, sulphate of soda, chlorid of magnesium, and carbonate of lime, provided an excess of free carbonic acid was secured during the whole reaction. The mode of alteration in the chemical composition of these brines, then merely indicated, appeared to me of sufficient interest to merit some more detailed illustration, particularly for the following reasons.

The brines of Onondaga issue from rocks of the Upper Silurian age; they indicate with great probability, by their composition, concentration, and copiousness, a close connection with quite an extensive salt deposit‡ of that age, and thus may represent, to a certain extent at least, the constitution of a quite prim-

* Soluble silicates of potassa and soda, and carbonate of soda, etc., have been for years applied to accomplish similar alterations, for technical purposes.

† Contribution to the Chemistry of the Mineral Springs of Onondaga, N. Y. —Syracuse, Feb., 1866; and also this Journal, September and November, 1866.

‡ The brine furnished for the manufacture of salt since 1797 may be set down as being equal to at least two hundred millions of bushels of salt (each 56 lbs.); nearly ¾ may be counted for the last ten years; counting one cubic foot of solid salt equal to 140–142 lbs., about 15·5 cub. ft. will make one heavy ton (2240 lbs.); the amount of salt therefore removed since 1797 from that locality is equal to five millions of heavy tons, or seventy-five to eighty millions cub. ft. of solid salt.

itive salt formation; consequently any investigation of their changes promised some chance of obtaining information concerning the nature and extent of the various causes assigned for the existing differences in the chemical composition of the oceanic waters and the saline deposits of earlier and recent date.

Taking this view I intend to treat, in the following pages, of some changes, which the brines in question and those of similar composition* may suffer in regard to their chemical composition, adopting the following order:

First, changes in consequence of concentration; second, changes due to an access of carbonate of magnesia in presence of free carbonic acid, concluding with some generalizations.

I. *Changes in composition due to concentration.*—The brines in question contain from 16 to 17 per cent of saline matter; they are clear, colorless, and highly charged with carbonic acid gas when they issue from the wells; exposed to air they soon become turbid, deposit a small amount of hydrated peroxyd of iron and after some time become clear again.

A separation of gypsum and, under certain conditions,† of carbonate of lime also takes place subsequently, first as an incrustation on the sides of the vessels, afterward, particularly toward the point of saturation, as a film of crystals, partly swimming upon the surface, partly floating about the bottom. No further visible changes, aside from the increasing separation of chlorid of sodium and gypsum, are noticeable for some time until the evaporation practically ceases.‡

The following analytical statements may convey some idea of the changes within the liquid during the process of concentration at ordinary temperatures.

	I.	II.	III.	IV.	V.
Sulphate of lime,	0·5772	0·4110	0·1146	0·0304	0·0264
Chlorid of calcium,	0·1533	0·2487	2·6959	7·3420	10·4690
Chlorid of magnesium,	0·1444	0·2343	2·7513	6·2926	10·5020
Chlorid of potassium,	0·0119	0·0194	0·8177	undet.	3·3769
Bromid of magnesium,	0·0024	0·0039	undet.	undet.	0·4485
Iodine, etc.,	traces	undet.	"	"	undet.
Carbonic acid,	undet.	"	"	"	"
Chlorid of sodium,	15·5317	25·7339	20·1006	10·0901	8·7441
Carb. of protox. of iron,	0·0044	undet.	undet.	undet.	undet.
Water,	83·5	73·3	73·4	....	....

The analytical examinations being designed merely to answer certain questions, were not, as a general rule, carried out farther than is directly stated.

* Karsten's second class of brines. The principles on which Karsten has based his classification are still acceptable for practical purposes; yet chemists might prefer at the present day to reverse simply his orders, for there seems, according to our present information, but little doubt that the brines of his first class are more or less derivatives of his second class, i. e., of those containing chlorid of calcium.

† This Journal, II, xlii, 372, Nov. 1866.

‡ Farther details in regard to these questions are given in my paper "On the manufacture of Solar Salt, etc." Syracuse, Dec. 1863, page 17.

Analysis No. I is from the brine of a particular well at Syracuse, and represents that brine, as far as figures have been given, in its original composition; analysis No. II is obtained from that same brine after being brought simply to the point of saturation; analyses Nos. III, IV, V, are from mixtures of brines from different wells; they were collected at different stages of concentration and the subsequent separation of the crystallized chlorid of sodium, etc. The discrepancies in regard to the varying relative proportions of the chlorids of calcium and magnesium observable in the foregoing statements are due to some slight differences in the composition of the original material subjected to evaporation. I stated on a former occasion that within a certain limit these brines differ somewhat in regard to the relative proportions of the deliquescent chlorids; these differences, although most trifling from a practical point of view so far as the brines are concerned, appear quite conspicuous, when the mother-liquors (or bitterns) are compared. A liquid of the composition of No. V has practically ceased to evaporate in our section of the country; its volume is constantly fluctuating, being influenced by the season and the condition of the atmosphere.

A glance over the various analyses suffices to show, that a large amount of sulphate of lime ($\frac{1}{4}$) is rendered insoluble before the crystallization of chlorid of sodium begins, and that the deliquescent chlorids of calcium and magnesium in Nos. III, IV, V, have materially interfered with the solubility of both chlorid of sodium and sulphate of lime. A closer examination into the relative proportions of the principal components of the liquids Nos. I and V proves that at least more than one thousand parts of chlorid of sodium and more than forty parts of the sulphate of lime must have been separated from solution No. I before a residual liquid of the composition of No. V could be obtained. Testing the separated saline mass on the other hand, we notice the following facts, which are a true type of the recognized condition in natural saline deposits; the chlorid of sodium which crystallizes out of the solution No. I during a continued evaporation, being impregnated with the remaining mother-liquor, contains always more or less of the chlorids of calcium and magnesium, besides the whole amount of the sulphate of lime separated. The relative proportion in which these two chlorids may be retained within the separated chlorid of sodium, corresponds closely with that of the original brine, while the entire amount of both present in the crystalline mass, is governed by particular circumstances; slow evaporation and steadiness of temperature, for instance, by favoring well developed individual crystals, react most decidedly toward their exclusion. The sulphate of lime, on the other hand, varies in quantity in the different layers of crystals

of chlorid of sodium, throughout its whole mass; in cases where the evaporation has been started with a brine like No. 1 above, it forms the basis of the whole saline deposit and gradually decreases in quantity toward the close of evaporation, or within the upper layers.

I deem it of some interest, and therefore call attention here to the great resemblance in chemical composition of the saline liquid, No. v above, and some of the mineral waters of Canada, as shown by T. S. Hunt's analyses, particularly No. 4.*

It will be noticed that the results of evaporation previously stated will serve as a strong argument in favor of the view advanced concerning the probable origin of that whole class of mineral waters, namely, that they originate from mother-liquors or bitterns of the saline residue of marine evaporations of the Silurian age. The essential difference in the instances alluded to is apparently merely one of concentration. The Upper Silurian rocks in our vicinity are similarly impregnated with these assumed mother-liquors (or re-solutions of the upper layers of salt deposits) as the Lower Silurian rocks around the north and northwestern shores of Lake Ontario are represented to be.† The similarity in composition between the saline waters from both localities‡ manifests itself even in the peculiar variations in the relative proportions of the most characteristic compounds, particularly the deliquescent chlorids of calcium and magnesium, as may be seen from the following analyses of waters taken from the vicinity of Syracuse.

One hundred parts contain—

	A.	B.	C.
Sulphate of lime, . . .	0·0058	0·0794	1·7000
Chlorid of calcium, . .	4·8200	6·1143	8·4800
Chlorid of magnesium, . .	0·9281	1·7844	0·7830
Chlorid of potassium, . .	undet.	undet.	0·3530
Chlorid of sodium, . .	15·2288	8·7263	9·2430
Carbonate of iron, etc., . .	traces	traces	undet.§
Water, ...	79·0	83·3	979·441
	100·0000	100·0000	1000·0000

* This water is from the vicinity of the bay of Quinte; 1000 parts contain of

Chlorid of sodium, - - - - - -	17·4000
" potassium, - - - - - -	undet.
" calcium, - - - - - -	9·2050
" magnesium, - - - - - -	9·4843
Bromid of sodium, - - - - - -	undet.
Sulphate of lime, - - - - - -	" etc.

Table I, waters of first class; this Journal, II, xl, 44, July, 1865.

† T. S. Hunt, (loc. cit.).

‡ The question in regard to their real source so far as particular geological epochs are concerned, is, we presume, in many cases still open to discussion.

§ The presence of this large amount of sulphate of lime, and of carbonates is apparently due to an admixture of drainage waters from surface percolation, which pass through gypseous shale and diluvial drift.

If such relations exist in regard to the natural saline bitterns of both localities, as the history of the liquid No. V suggests, we may be entitled to assume, considering the area of actual observation the existence of extensive salt deposits within the Silurian basin. To advance here opinions in regard to their particular origin in either case, would be of little value, so long as careful local examinations are still wanting; since marine evaporations or salt deposits may occur independently of each other, between the successive strata within the same basin;* and irregularities and ruptures in the level of the rocks, caused by physical and chemical reactions from within and without, are quite frequently observed in the vicinity of salt deposits. Moreover, inferences drawn merely from the level of the rocks and the depths of the borings without a previous careful tubing of the latter are not less unreliable, than the conclusions adduced from the differences of temperature between the mean temperature of the locality in question and that of the saline waters issuing from the springs or wells; for the common rule of drainage may be changed by fissures, etc., and causes which produce alterations of temperature in consequence of chemical reactions are never wanting in circumstances like those under consideration. The decided differences in regard to the relative proportion of the saline waters, No. I, p. 80, and A and B, p. 82, which occur within quite a limited territory will in all probability find a less acceptable explanation, in the opinion of many, by supposing a difference in the chemical character of intercepting strata, than by assuming either entirely different sources or independent local secondary influences, similar to those for instance at Stassfurt, aided by irregularities in the level of the rocks of the same geological period,† for the brines of Syracuse are characterized by their small percentage of deliquescent chlorids of nearly *corresponding* quantity and their proportion of sulphate of lime, marks of particular significance considering the surrounding conditions.

II. *Changes in composition due to the reaction of carbonate of magnesia upon chlorid of calcium and sulphate of lime in the presence of carbonic acid gas.*—On a previous occasion I described the mode of action and the conditions under which carbonate of magnesia would act upon chlorid of calcium and sulphate of lime, both in the presence and in the absence of chlorid of sodium; only the first case belongs to the present discussion. It remains here merely to illustrate more in detail such changes as

* Two independent rock salt deposits, for instance, have been found in the Thuringian basin; one in the Permian rocks (Zechstein), the other in the Triassic rocks (Muschelkalk). (F. Bischof, Steinsalz werke bei Stassfurt. Berlin, 1864, p. 5.)

† At Stassfurt, a layer of magnesian compounds several hundred feet in thickness occurs above the rock salt, while at Schonbeck (belonging to the same deposit) this layer is wanting. (F. Bischof.)

have been before indicated. Our brines contain both chlorid of calcium and sulphate of lime, and are highly charged with free carbonic acid; they are thus liable to undergo alterations in both the directions mentioned.

The circumstances under which these two reactions take place leave it somewhat doubtful to which particular reaction the removal of the chlorid of calcium may be ascribed, whether to a mere substitution of the calcium of the chlorid of calcium by magnesium, or indirectly to the decomposition of the sulphate of lime into sulphate of soda, carbonate of lime and chlorid of magnesium; and the subsequent reaction of the sulphate of soda thus formed, upon the chlorid of calcium, reproducing thereby again sulphate of lime and chlorid of sodium, previously decomposed. Whatever the order or the extent of either of these two distinct and available modes of changing the composition of the brine may have been in this instance, a corresponding amount of chlorid of magnesium and of carbonate of lime are in either case the final products; and as carbonate of lime rapidly separates (settling), in the case of more saturated solutions, an addition of chlorid of magnesium* equivalent to the amount of chlorid of calcium removed, remains practically the only material acquisition of the brine. Quite different are the final results, so soon as the accessible carbonate of magnesia begins to exceed the chemical equivalent of the chlorid of calcium; for by the aid of free carbonic acid† the sulphate of lime will be decomposed and thus on account of the presence of chlorid of sodium, every additional amount of the carbonate of magnesia will produce a corresponding amount of sulphate of soda, chlorid of magnesium and carbonate of lime, which compounds remain intact; these changes may thus continue until all the sulphate of lime has been decomposed. The amount of sulphate of soda, etc., liable to be produced by the foregoing reaction, depends apparently entirely upon the supply of both, i. e., carbonate of magnesia and sulphate of lime.

To render these changes more striking I will illustrate them by numerical statements:

* Attention has been called to the fact as being quite remarkable, that no brines containing chlorid of calcium without containing also chlorid of magnesium have been noticed; the reverse occurs as is well known quite frequently. Brines from the States east of the Mississippi containing no chlorid of calcium have not thus far come under my observation, while such brines seem to occur quite frequently in the States west of that river, as examinations of brines and salt from Nebraska, Kansas and Arkansas, etc., have proved to me; they also contain frequently considerable quantities of sulphate of soda, etc.

† The amount of carbonic acid noticeable in mineral waters when issuing from springs, or forced out from wells, gives rarely a correct idea of the amount at work, for their passage upward over rough surfaces, and their exposure to higher temperatures, etc., cause its partial liberation by escape through the soil, etc.

	A.	B.	C.	D.
Sulphate of lime, . .	0·5772	0·5772	0·2885	....
" of soda, . .	....	....	0·2900	0·5912
" of potassa, .	....	....	0·0139	0·0139
Chlorid of calcium, .	0·1533	....	....	....
" of magnesium, .	0·1444	0·2756	0·4772	0·6786
" of potassium, .	0·0119	0·0119	....	....
Bromid of magnesium, .	0·0024	0·0024	0·0024	0·0024
Chlorid of sodium, . .	15·5317	15·5317	15.3028	15·0445
Water, ...	83·57	83·57	83·57	83·57
Carbonate of lime, . .	....	0·1381	0·3502	0·5625

A represents the brine with its original composition; B represents the same brine subjected to the action of but 0·1160 carbonate of magnesia dissolved in water containing carbonic acid gas; this amount of carbonate of magnesia is equivalent to the chlorid of calcium present; C represents the same brine after the reaction of 0·2943 carbonate of magnesia, causing besides the removal of chlorid of calcium also that of one half of the gypsum present; it changes chlorid of potassium into sulphate of potassa and leaves besides a corresponding excess of sulphate of soda. D represents the brine after the entire decomposition of the chlorid of calcium and the sulphate of lime; the latter is represented by sulphate of soda in solution, formed of course partly at the expense of the chlorid of sodium; 0·4725 neutral carbonate of magnesia, aided by carbonic acid gas, are required to cause such complete changes. The whole amount of lime as chlorid and sulphate in the original brine is changed into carbonate.

The carbonate of lime formed during each stage of progress has been noted separately; the largest proportion, in instances like those presented above, would settle soon after its formation, since the degree of its solubility in this case depends upon the concentration of the saline liquid, the temperature and the time of its formation, leaving the particular influence of the carbonic acid gas as a means of solution out of consideration.

Viewing these four statements from Karsten's standpoint we notice that while A belongs undoubtedly to his second class of brines, B, C and D, must be counted to those of the first class. Accepting on the other hand, the fact that such changes are going on in saline solutions in our Silurian rocks, we must concede that the saline matter of the Silurian ocean may even change within the Silurian rocks to such a degree as to resemble those of the present ocean; for, whatever essential compounds of the latter are not mentioned in the above statements, we must acknowledge can be constructed from their components present, making allowances for influences of temperature, and concentration, and for the peculiar view taken in regard to chemical

affinity under both of these circumstances; the difference in the *relative proportions* of the *various compounds* depends on entirely different causes.

The particular conditions required to render such a change of the brine possible, are, it can scarcely be denied, abundantly supplied, particularly in consequence of the extensive exposure of our Silurian rocks. Chlorid of sodium has been and is still performing a most important part in the disintegration of a large number of rocks, by chemical and particularly by mechanical forces in consequence of its hygroscopic quality.

Chlorid of sodium and sulphate of lime are almost everywhere associated; they occur not only as more or less well defined deposits of varying extent, but they must originally have pervaded every sedimentary rock from the lowest Silurian to the latest marine formation. Subsequently they have found access to many formations of a later date and different origin by the ascent of percolating waters. Most of these rocks contain, more or less abundantly, compounds of magnesia, particularly carbonates,* and have thus uninterruptedly yielded quantities of that substance to solutions, wherever such powerful disintegrating agencies as change of temperature, access of moisture and free carbonic acid have been at work; the destruction of these rocks is a mere matter of time. Many sedimentary rocks may have been exposed to these influences temporarily, perhaps in a less indurated state, and consequently have presented conditions most favorable for transformation and subsequent extraction; circumstances which may sometimes account for the total or partial abstraction of sulphate of lime from a number of sedimentary rocks of marine origin.†

Relying here, more on the duration than on the intensity of the action, I believe that the final results of reactions like those considered in the foregoing discussion, must *in common with other causes*, have exerted an important bearing on the composition of the marine waters, during the development of our present surface-configuration; and they may in particular instances have assumed proportions sufficiently extensive to account even for more localized accumulations of sulphate of soda, in connection with

* Researches of Ebelman, confirmed by T. S. Hunt, have proved that magnesia and lime are first abstracted, by means of carbonic acid, from even basaltic and similar rocks and that in the case of labradorite, the removal of these two alkaline earths was even more complete than that of the alkalies, (this Journal, II, xxxix, 181, March, 1865); a series of analyses of waters from along the N. Y. Central railroad by Dr. C. F. Chandler (New York, 1865), as well as some of my own analyses furnish a direct proof of the fact, that the carbonate of magnesia enters in an unusual proportion into the composition of a large number of our spring waters.

† Mineral waters issuing from rocks in the city of Oswego (gray sandstone) along the Oswego river contain large percentages of chlorid of sodium, besides the chlorids of magnesium and calcium; they are free from sulphate of lime. Analysis gives, in 1000 parts, NaCl 5·622, MgCl 0·140, CaCl 0·3152, etc.

chlorid of sodium as well as with other saline compounds. The whole reaction of carbonate of magnesia, in the presence of carbonic acid gas, upon brines like ours, resembles somewhat, so far as some of the final results are concerned, that of carbonate of soda provided the latter does not exceed in chemical equivalents the chlorid of calcium and sulphate of lime present, sulphate of soda, and carbonate of lime being formed in both instances; they differ only in one essential point; in case of the addition of carbonate of soda the chlorid of calcium is simply eliminated (only traces of carbonate of magnesia being produced) and its place supplied by a corresponding amount of chlorid of sodium, while in the case of the addition of carbonate of magnesia the chlorid of calcium is replaced by a corresponding quantity of chlorid of magnesium. The following statement demonstrates the changes due to the addition of an amount of carbonate of magnesia or of carbonate of soda chemically equal to the amount of chlorid of calcium present, since, as soon as that point is passed both carbonates produce sulphates of soda, as long as sulphate of lime remains in excess.

	1.	2.	3.	4.
Sulphate of lime, . .	0·5772	0·5772	0·5772	0·7652
Chlorid of calcium, . .	0·1533	....	....	....
" magnesium, .	0·1444	0·2756	0·1444	0·1444
" potassium, . .	0·0119	0·0119	0·0119	0·0119
Bromid of magnesium, .	0·0024	0·0024	0·0024	0·0024
Chlorid of sodium, . .	15·5317	15·5317	15·6933	15·6933
Water, ...	83·57	83·57	83·40	84·10
Carbonate of lime, . .	....	0·1381	0·1381	....

1 represents the original brine; 2 represents this brine treated with the necessary amount of carbonate of magnesia; 3 represents this brine (1) treated with a corresponding amount of carbonate of soda; 4 represents the original brine simply treated with an additional amount of sulphate of soda. We can scarcely imagine the variety of brines and mineral waters which may result in the course of time from this or similar brines, under different geological conditions, particularly if we consider the consequences, which must result from a mere difference in concentration before or after such changes as we have discussed in these pages have been fully or partly accomplished.

Slim indeed are the chances of learning anything more definite about the original composition of the saline mass of the oceanic waters of the Silurian age from our mineral waters and brines; since the extensive exposure of our Silurian rocks renders them subject to important changes by disintegration, and causes them to react decidedly upon percolating saline solutions.

Syracuse, March 14, 1867.

ART. XI.—*Notice of a new Genus of fossil Sponges from the Lower Silurian;* by Prof. O. C. MARSH, of Yale College.

WITHIN the last few years several specimens of a remarkable fossil have been found in limestone of lower Silurian age in Franklin county, Kentucky. Although generally recognized as *Amorphozoa* by paleontologists who have seen them, and evidently new to science, no description of them appears to have been published hitherto, except a brief notice by Prof. D. D. Owen, who proposed for them the name of *Scyphia digitata.**

The Cabinet of Yale College contains a very perfect specimen of this fossil, recently obtained from Prof. Hovey of Wabash College; and the writer had previously an opportunity of examining, in the collection of Mr. Sydney S. Lyon, of Jeffersonville, Indiana, a large and fine specimen, the original from which casts have since been supplied to the Yale and other museums, by Prof. Ward of Rochester.

In general appearance, and nearly all important characters, these two specimens are very similar. The form is that of a short vase, or cup, with a row of arms extending outward and downward from the lateral surface. These arms are hollow, and open directly into the main or central cavity, which is apparently larger than in any other known sponge, recent or fossil.

The specimen in the Yale collection is about six inches in diameter, and three in height. It has nine arms of nearly equal size and length, all with openings at their extremities. The base has a small protuberance near the center, but no other indication of attachment. The other specimen has eleven arms, and is nearly eleven inches in diameter, by three and a half in height. Both specimens are externally silicified. The main orifice, or mouth, is oval in form, and in the smaller specimen is situated at the end of a short neck, about one and one-half inches above the bases of the arms.

As these specimens are without doubt generically distinct from any yet described, the name *Brachiospongia* is proposed for the genus they represent; and, since there is apparently more than one species included under the name *digitata*, the trivial designation of *Rœmerana* may be added, in honor of Prof. Ferdinand Rœmer, of Breslau University, whose investigations have thrown so much light upon paleozoic sponges. The specimen in the Yale Cabinet may be regarded as typical of this species. Should the form represented by the large specimen already noticed prove a distinct species, this may appropriately be named *Brachiospongia Lyonii*, from Mr. S. S. Lyon, the discoverer of these interesting fossils. A full description of these specimens, with illustrations, will appear in an early number of this Journal.

New Haven, Ct., May 25th, 1867.

* Second Report on the Geology of Ky., p. 111.

ART. XII.—*Crystallogenic and Crystallographic Contributions;* by JAMES D. DANA. No. IV,* *On a connection between Crystalline form and Chemical constitution, with some inferences therefrom.*

AMONG oxyds, the protoxyds, like the metallic elements, are characteristically *isometric*† in crystallization. The sesquioxyds are as characteristically *hexagonal*, this being the form of the sesquioxyds of iron, aluminum, and chromium. The deutoxyds are typically *tetragonal*, as seen in the deutoxyd of tin (tin ore) and of titanium (rutile and anatase). There are other forms among protoxyds, sesquioxyds and deutoxyds; for example, ZnO is hexagonal; TiO^2 in brookite, and MnO^2 in pyrolusite are orthorhombic; but these cases, as the following observations make apparent, may be regarded as a consequence of polymerism —a principle that has been recognized by others as underlying dimorphism.

Regarding the atom of oxygen as double in its fundamental

* The preceding papers in this series by the writer are not numbered. They are: I, On the Formation of Compound or Twin crystals, vol. xxx, 275, 296, 1836; II, On certain laws of Cohesive Attraction (as illustrated by crystals); II, iv, 364, v, 100, 1847, 1848; III, On the Homœmorphism of mineral species of the trimetric [and other] systems, II, xviii, 35, 131, 1854, with the antecedent papers in xvii, 85, 210, 430.

† I propose to employ in the forthcoming edition of my Mineralogy the terms *Isometric*, *Tetragonal* (having a square base), and *Orthorhombic* (erect on a rhombic base), in place respectively of *Monometric*, *Dimetric*, and *Trimetric*. *Monometric* describes a line better than a cube; the hexagonal prism is as much *dimetric* as the square prism; and the oblique prisms are as truly *trimetric* as the right rhombic. It is very desirable that the technical terms of science should be uniform over the world, as far as possible, and that authors should be willing to yield their own usage for the sake of uniformity. The terms adopted appear to be the best that have been proposed, and have already extensive use in Europe. *Isometric* is Hausmann's term; *tetragonal* and *hexagonal*, with *rhombic*, are employed by Naumann. Mohs's terms *pyramidal* for the tetragonal system, and *prismatic* for the orthorhombic, are exceedingly bad, as there are pyramids among isometric, orthorhombic and hexagonal forms, as well as the tetragonal; and prisms in all the systems excepting the isometric.

There is additional reason, for our proposed change, in the natural relations of the systems of crystallization. For the similarity in the names *monometric*, *dimetric*, *trimetric* (the latter two the *monodimetrischen* and *trimetrischen* of Hausmann) implies a fundamental relation in the forms; while the true classification is as follows: (1) *Isometric*, including the isometric system, peculiar in the absence of double refraction or polarization; (2) *Isodiametric* (from ἴσος, *equal*, and *diameter*), including the tetragonal and hexagonal forms (alike named from the shape of the base), characterized by equal transverse axes or diameters, and uniaxial polarization; and (3) *Anisometric* (from ἄνισος, *unequal*, etc.), including the remaining systems, and distinct in having the axes or diameters all unequal, and biaxial polarization.

Monoclinic, *Diclinic*, *Triclinic* (from Naumann) I would retain, as they express admirably the relations of the systems. *Clinorhombic* is often used for the monoclinic system, and is well enough. But *clinorhomboidal* for the triclinic would not be desirable, as the French commonly use the word *rhomboidal* where others use rhombic; and the *diclinic* could have no corresponding name, unless it be *clinorectangular*, which would be very objectionable.

nature, the number of atoms of oxygen (or the negative element) in the protoxyds is 2; in the sesquioxyds 6, or a multiple of 3; in the deutoxyds 4.

It appears from a survey of all hexagonal and tetragonal compounds to be a general fact, that the number of atoms of the negative element is 3, or a multiple of 3, in the former; and 2, 4, or a multiple of 4, in the latter; and that, consequently, the hexagonal and tetragonal systems are based on these numbers, respectively, their symmetry being a consequence of it.

1. *Tetragonal species, and the number* 4.—Among *unisilicates*—the silicates which have the ratio 1 : 1 between the oxygen of the bases and silica (SiO^2), and the number of atoms of oxygen 4, or its multiple—tetragonal species are common; while none occur among the *bisilicates*, in which the ratio is 1 : 2, and the number of atoms of oxygen is 3, or its multiple. There are none also among the anhydrous carbonates, which likewise have the oxygen ratio 1 : 2. But among these bisilicates and carbonates there are examples of *hexagonal* species. The compounds $\dot{C}a\dot{W}$ (scheelite), $\dot{P}b\dot{W}$ (scheeletine), $\dot{P}b\dot{M}o$ (wulfenite), $\dot{Y}^3\dot{P}$ (xenotime) are tetragonal, the last having 8 of oxygen (or 16 if doubled) and the others 4. Matlockite (PbCl+PbO) is tetragonal, while PbI+2PbO is hexagonal, and PbCl+2PbO is orthorhombic. Cerasine (PbCl+$\dot{P}b\dot{C}$) is tetragonal; and the number of atoms of the negative elements, O, Cl, is 4. Hausmannite is tetragonal, and with the usual formula $\dot{M}n\dot{M}n$ has 4O. Yet the formula is better written $\dot{M}n^2\dot{M}n$, for this corresponds with its close relation in form to the RO^2 or deutoxyd group, while $\dot{M}n\dot{M}n$ is a formula of the isometric spinel group. Similarly, the tetragonal species chalcopyrite has the formula 2(Cu, Fe)S+FeS^2. Braunite, taking the most recent formula for it, that of Rammelsberg, $(Mn, Si)^2O^3$, is apparently an exception. Its composition, as Rammelsberg shows, corresponds to $3\dot{M}n+\dot{M}n+\dot{S}i$, and this formula has 12O, which is a multiple of 3, and satisfies the principle under illustration. But the true arrangement of the constituents makes it not a sesquioxyd, as above, but a *deutoxyd* like hausmannite, which it approaches in its tetragonal form; for the formula may be $2\dot{M}n^2\dot{M}n+\dot{M}n\dot{S}i$, which is equivalent to 2 of hausmannite and 1 of a silicate analogous to the tetragonal species zircon ($Zr\dot{S}i$).* The deutoxyd of manganese, MnO^2 (pyrolusite), is orthorhombic, and approximately isomorphous with orthorhombic TiO^2 (brookite), the former having for the angles of

* Hausmannite approaches more closely the anatase form of TiO^2 than the rutile form, the angle between *O* and the plane made 1-*i* in anatase being 119° 22′, and *O* : 1 (which might as well be 1-*i*) in hausmannite being 121° 3′. Braunite is much nearer cassiterite, rutile, and zircon, the corresponding angles for *O* on a pyramidal plane in these four species being, respectively, 135° 26′, 136° 26′, 137° 40′, 137° 50′. Thus the anatase and rutile form of TiO^2 are severally represented by hausmannite and braunite.

the prism *I*, and the domes 1-$\breve{\imath}$, 1-$\breve{\imath}$, respectively, 93° 40′, 104° 22′, 107° 54′; and the latter for the corresponding angles 93° 16′, 96° 46′, 99° 50′. MnO^2 in the tetragonal state is unknown except when it is in combination with 2MnO, as in hausmannite. The protoxyd of manganese, MnO, it may be remarked, is isometric, like MgO, it having been obtained artificially in octahedrons and cubo-octahedrons by Deville (C. R., liii).

Among artificial compounds, there are the following tetragonal species all conforming to the principle stated:

KF + HF; $\dot{B}e\bar{S}$+4aq; $\dot{N}i\bar{S}$ + 7aq; $\dot{N}i\bar{S}$ + 6aq; $\dot{N}i\bar{S}e$ + 7aq; $\dot{Z}n\bar{S}e$+7aq; $(\dot{K},\dot{H})^3\bar{P}$; $(\dot{A}m,\dot{H})^3\bar{P}$; $(\dot{K},\dot{H})^3\bar{A}s$; $(\dot{A}m,\dot{H})^3\bar{A}s$; $\dot{C}a\bar{C}$+2aq; $(\dot{A}m+\dot{H})\bar{B}^2$+3aq; NaO, IO^7; KCl+CuCl+2aq; AmCl+CuCl+2aq; $\dot{A}g\bar{S}$+$2NH^3$, $\dot{A}g\bar{C}r$+$2NH^3$, $2\dot{K}\bar{A}c$ (acetic acid)+$\dot{C}u\bar{C}$+12aq; $\dot{C}a\bar{A}c$+$\dot{C}u\bar{A}c$+8aq, $\dot{K}\bar{A}c$+$2\bar{U}\bar{A}c$+2aq, $\dot{A}g\bar{A}c$+$2\bar{U}\bar{A}c$+2aq; $(\frac{1}{2}\dot{C}a+\frac{1}{2}\dot{H})^2\bar{T}$ (tartaric acid, containing 5O)+$\bar{S}b\bar{T}$+7aq.

Omitting a few complex organic compounds, these are all the tetragonal species in the two volumes of Rammelsberg's Crystallographic Chemistry excepting $\dot{A}g\ddot{C}l$, Hg^2Cl. Other examples might be mentioned, but the above are fully sufficient.

The correspondence with the law for tetragonal species is so general that we may reasonably believe that the apparent exceptions, where the composition and crystallization are correctly given, may be brought into conformity to it by an application of one or the other of the following principles.

a. The principle of polymerism.—Hg^2Cl is Hg^2Cl^2 in the new system of chemistry; and if the whole is doubled, it becomes $\dot{H}g^4\dot{C}l^4$, which is probably the true formula of this species in the tetragonal state, the only crystalline state yet known.

b. Part of the ingredients may be only accessory, or subordinate to a dominant part which determines the crystallization.—Water is commonly admitted to be present in this way in most of the compounds in which it occurs; although essential to the species, it is subordinate, crystallogenically at least, to the rest. Water is now believed to be not the only substance that may play the part of indifferentism in compounds, and many formulas have of late been written by chemists admitting this. Apophyllite is a tetragonal species consisting of $\dot{R}+2\breve{S}i+2\dot{H}$. Making the water basic, there is still no conformity to the type of either the unisilicates or bisilicates, the oxygen ratio for the bases and silica being 3 : 4. If half the water be regarded as basic, and the formula be written $(\dot{R},\dot{H})^2\breve{S}i+\dot{H}\breve{S}i$, it is made to consist of a dominant part which is a unisilicate analogous to the tetragonal species meionite, mellilite, etc., and a bisilicate which is a kind of opal or waterglass, well known to be a "colloid," or uncrystallizable, and which therefore might well have no effect toward modifying the crystallization as determined by the other part.

2. *Hexagonal species, and the number* 3.—Hexagonal species have been stated to occur among the sesquioxyds (as Fe^2O^3, Al^2O^3, Cr^2O^3); the bisilicates (as in beryl, eudialyte, dioptase, pyrosmalite, chabazite, gmelinite); and the carbonates (in calcite, and the allied species); in which compounds the number of atoms of oxygen is 3, or a multiple of 3. Other examples are:

Pyrargyrite and proustite, $3AgS+(Sb, As)^2S^3$, in which the number of atoms of sulphur is 6; gibbsite $\dot{A}l\dot{H}^3$; alunite $\dot{K}\ddot{S}+3\dot{A}l\ddot{S}+6aq$; apatite $3\ddot{C}a^3\ddot{P}+CaCl$; coquimbite $\dot{F}e\ddot{S}^3+9aq$; Al^2Cl^3+12aq; $\dot{M}g\ddot{S}+6aq$; $\dot{A}l\ddot{S}^3+27aq$; $SrOS^2O^5+4aq$, and the corresponding salt of lime, and of lead; $\dot{K}\dot{N}$; $\dot{N}a\dot{N}$; $(\ddot{C}a+\dot{H}^2)\ddot{C}$; AgO, $ClO^7+4\dot{H}$; $3NaCl+IrCl^3+24aq$; $KCl+2MgCl+12aq$; $MgCl+PtCl^2+6aq$.

The exceptions to the principle are to be accounted for in the same manner as those under the tetragonal system. Along side of the hexagonal sesquioxyds, Fe^2O^3, Al^2O^3, Cr^2O^3, there is the hexagonal protoxyd ZnO, similar in angle. Applying the principle of polymerism and writing the formula Zn^3O^3, it then has, like the sesquioxyds, 3 of O. This view of the protoxyd is abundantly illustrated and sustained among the silicates. For the constitution of the larger part of them (garnet, scapolite, epidote, etc.) is based on the mutual replacement of 1 of sesquioxyds (R^2O^3), and 3 of protoxyds ($3RO$); and this mutual replacement signifies isomorphism of R^2O^3 and R^3O^3. Again, graphite, or *hexagonal* carbon, has been shown to have its atomic weight nearly three times as great as that of ordinary carbon; and it is altogether probable, therefore, that in this hexagonal state carbon is C^3, in accordance with the principle in view. Hexagonally crystallized water, on the same ground, is not HO, but H^3O^3. ZnS occurs both in isometric and hexagonal forms; and while the former may be simply ZnS, the latter should be Zn^3S^3; and so for the hexagonal sulphid of Fe, Ni, Cd, we should have Fe^3S^3 (troilite, pyrrhotine); Ni^3S^3 (millerite); Cd^3S^3 (greenockite); and similarly Ni^3As^3 (copper nickel); Ni^3Sb^3 (breithauptite).

3. *Isometric system.*—The number of atoms of the negative element in isometric species appears to be either 1, 2, 3, 4, or a multiple of 3 or 4; and this diversity accords with the twofold nature of a cube; that is, (1) an equiaxial square prism, and (2) (if a diagonal be made vertical) a rhombohedron of 90°; for it has this double relation to other forms. Accordingly, isometric forms occur among protoxyds, protosulphids, protochlorids, etc.; also deutoxyds; also unisilicates; in leucite, analcime; also in—

$\dot{M}g^3\ddot{B}^4$, or boracite; $\dot{A}s$; $\dot{S}b$; $\dot{N}a\ddot{C}l$; $\dot{K}\ddot{B}r$; $\dot{N}a\ddot{B}r$; $\dot{N}i\ddot{C}l+6aq$; $\dot{C}u\ddot{C}l+6aq$; $\dot{C}o\ddot{B}r+6aq$; $AmCl+SnCl^2$; $KCy+AgCy$; $3\dot{N}a\ddot{C}+\ddot{C}r\ddot{C}^3+9aq$; the alums, which have 160, besides 240 in the water; $\dot{N}a\dot{A}c+2\ddot{U}\dot{A}c$; $\dot{N}a\dot{W}+\dot{W}\dot{W}$.

Important chemical and crystallographic conclusions flow from

the principle which has been explained, if it is sustained, as we believe, by the facts. A few only are briefly touched upon.

1. It follows that the hexagonal state of the *elements* may be one corresponding to 3R, or $3n$R; that while zinc in the isometric state if such exists (about which there is doubt) is Zn; in the hexagonal it may be Zn^3, the same state in which it exists in hexagonal oxyd of zinc. So also Pd, As, Sb, may represent the isometric state of the elements palladium, arsenic, antimony; but Pd^3, As^3, Sb^3, the hexagonal; and so for other cases.

2. The oxyd of copper, CuO, which may also be written CuO^2, is dimorphous, it occurring both in isometric and orthorhombic forms; and the orthorhombic form is closely isomorphous with TiO^2 in brookite—$I:I$ and $I:\frac{1}{2}$ in the oxyd of copper being respectively 99° 39′ and 126° 29′, and in brookite 99° 50′ and 126° 15′. This relation to TiO^2 shows that the orthorhombic state of the cupric oxyd should have the formula CuO^2, or that of a deutoxyd, and the isometric alone that of CuO. And it indicates further that the element copper may exist theoretically, if not actually, in two corresponding polymerous states.

3. As long since illustrated by Laurent, the protoxyds RO, sesquioxyds R^2O^3, deutoxyds RO^2, and other grades of oxyds RO^3, RO^5 (and the same in corresponding chlorids, sulphids, etc.), in which 1 part of oxygen balances, in its affinity, 1, $\frac{2}{3}$, $\frac{1}{2}$, etc., parts of the basic element (as is seen on dividing by the number of atoms of oxygen so as to reduce the oxygen in all the above formulas to 1O), may be viewed as containing the basic element in as many different states as there are grades of the above compounds. For convenience these states may be designated by using the Greek letters as follows:

Formulas	RO RO	R^2O^3 $R_{\frac{2}{3}}O$	RO^2 $R_{\frac{1}{2}}O$	RO^3 $R_{\frac{1}{3}}O$	RO^5 $R_{\frac{1}{5}}O$
States of Basic element	R αR	$R_{\frac{2}{3}}$ βR	$R_{\frac{1}{2}}$ γR	$R_{\frac{1}{3}}$ δR	$R_{\frac{1}{5}}$ εR

or the *alpha*, *beta*, *gamma*, *delta* and *epsilon* states. It is observed that $3RO=R^3O^3$; $3(\beta RO)=R^3O^3$; $2(\gamma RO)=RO^2$; $3(\gamma RO)=\frac{3}{2}RO^2$; $3(\delta RO)=RO^3$; and so on: in other words, the *one* molecule R^2O^3 corresponds to *three* of βRO; and in $3(\beta RO)$ there are as many atoms of the basic element βR as of O.

Now, if a sesquioxyd occurs in *isometric* crystals, as supposed to be true of Fe^2O^3 (but reasonably doubted), that sesquioxyd is not Fe^2O^3, but may be $Fe_{\frac{2}{3}}O$. This is but the converse of the conclusion, stated above, that if a protoxyd occurs in *hexagonal* crystals it is not then RO, but may be R^3O^3. So in other cases: if oxyd of tin had an isometric as well as a tetragonal form, the former in the crystalline state should be $Sn_{\frac{1}{2}}O$, and only the latter

SnO^2. A metal in the different states R, $R\frac{2}{3}$, $R\frac{1}{2}$, has, accordingly, the same isomorphic power; and so also, 2R, $2R\frac{2}{3}$, $2R\frac{1}{2}$; and 3R, $3R\frac{2}{3}$, $3R\frac{1}{2}$. Hence under the principle explained—

RO, $R\frac{2}{3}O$, $R\frac{1}{2}O$ should be alike *isometric* in crystallization.

2(RO), $2(R\frac{2}{3}O)$, $2(R\frac{1}{2}O)$ may be *tetragonal* " "

3(RO), $3(R\frac{2}{3}O)$, $3(R\frac{1}{2}O)$ may be *hexagonal* " "

Quartz, which is hexagonal silica, should, according to the above, be $3(Si\frac{2}{3}O)$, or else $6(Si\frac{1}{3}O)$, and not $2(Si\frac{1}{2}O)=SiO^2$. SiO^2 is hence unknown in the crystalline state; and if ever obtained crystallized it will in all probability have one of the forms of TiO^2. Common uncrystallizing silica, or opal-silica, low in density, may be silica in the isometric form, or $Si\frac{1}{3}O$, but with so feeble crystallizing power as never to exhibit any thing but the so-called *colloid* condition. Whether isometric silicon, crystals of which have been obtained artificially, is simply silicon in the *alpha* state, or not, cannot be at once decided; for it is probable that diamond, which is isometric carbon, is equivalent to C^4, its density, and the product of the atomic weight by the specific heat, indicating this relation to graphite.* As "graphitoidal" silicon has turned out to be only isometric silicon, we have no chance for a comparison, like that with respect to carbon.

Anatase is probably TiO^2, and rutile Ti^2O^4, the density of the latter being 4·2, of the former only 3·9. The relations of hausmannite and braunite (p. 90, note) accord with this, the latter containing *two of hausmannite.* Brookite is intermediate in density, and in the temperature of origin, and hence may be $\frac{3}{2}(TiO^2)$. It would appear, therefore, that the species of *highest polymerous state,* rutile, forms at the highest temperature.

4. The views illustrated sustain the conclusion that the different states of elements represented above are fundamentally distinct: that Fe in the *alpha* state is related to all other metals that are in the same state, including K, Na (K_2, Na_2 in the new system of chemistry), as well as Mg, Ca, etc.; that Fe, Cr, Co, in the *beta* state are of the same group of elements with aluminum in alumina: that Fe, Mn, Cu, Pb in the *gamma* state should be classed with Ti, Sn.

5. Aid is given by the principle explained toward determining in many cases what are the accessory and what the dominant ingredients in a compound, and thence what should be regarded as its true constitution.

6. Crystallogeny hereby learns that *quadratic or tetragonal symmetry in crystals depends on quadratic symmetry, or the recurrence*

* For this inference with regard to the equivalent of carbon in the diamond I am indebted to Prof. G. F. Barker, who offered it while I was explaining to him the views contained in this paper.

of fours, in the number of atoms of the negative part of a compound; and hexagonal symmetry, in like manner, on the presence of triads or hexads of the same atoms. Moreover, on the view explained, the number of atoms of the more positive element or elements, in the simpler compounds at least, may be just equal to that of the negative. For since $3(\alpha RO)=R^3O^3$, $3(\beta RO)=R^2O^3$, and $3(\delta RO)=RO^3$, there are, in these oxyds, as many atoms of αR, βR, δR, as of O; and if the elements may exist in these divided states, they may thus make with the O the crystallogenic molecule.

The precise arrangement of the constituent atoms in a molecule subsisting in any case, and producing the characteristics and special dimensions of the crystal, yet remains to be explained. This much may be safely deduced: that the negative atoms must be grouped—and in the systems here referred to, under quadrate or hexad symmetry—at or toward one extremity of the molecule, and the positive at or toward the opposite; and that the molecule in this way derives its polarity—a characteristic abundantly manifested in the formation, the forms, and the physical natures of crystals,* though not often apparent in mechanical effects, and which is in accordance with the most fundamental of nature's laws. The different constituent elements or parts of a compound may differ in *degree* of negativity or positivity, and even the same element may be present in opposite states; such constituents would have their places accordingly, though with subordinate groupings according to special affinities.

In order not to be misunderstood, I here state, formally, what has been more than once implied in the foregoing, that, while, according to the principle advanced, tetragonal and hexagonal forms depend on the numbers 4 and 3, as explained, the presence of these numbers by no means necessitates the occurrence of these forms. Multitudes of examples illustrate this: the dimorphism of TiO^2 is one. I would also remark that I express no opinion as to whether the molecule of a compound consists of the positive and negative atoms simply juxtaposed, or whether these so-called atoms are composed of particles, and there is a different disposition in the molecule; and assert only that, whatever the fact on this point, there is tetragonal symmetry in the constitution of the molecule in the tetragonal system, and hexagonal in the hexagonal system.

I leave the subject here, without discussing at present the methods by which *orthorhombic* and *clinohedral* forms are produced; only observing that orthorhombic and monoclinic forms occur under all numbers of atoms of the negative element, from 1 (or 2) as in sulphur, upward; and, therefore, although polymerism may turn the 2 of sulphur (and so, other numbers) into various multiples of the same, yet that the production of these forms does not depend simply on numbers.

* See articles I and II referred to on page 89.

ART. XIII.—*The Glaciers of Alaska, Russian America;* by WILLIAM P. BLAKE.*

ON approaching the northwest coast of America from the west the mountain chain of the interior is seen to be lofty and alpine in its character. The ridges are sharply serrated, and rise here and there into needle-like pinnacles, giving an outline against the sky that contrasts strongly with the gently sloping sides of the truncated cone of Edgecombe, a fine extinct volcano which marks the entrance to the harbor of Sitka.

The rocky peaks of the interior rise above broad fields of snow, which give birth to numerous glaciers, while Edgecombe, and the ridges upon the coast, are in great part covered with a dense forest of pines and firs. No glaciers are found upon the coast at Sitka or south of it, for under the influence of the warm currents of the Pacific, the climate is comparatively mild, while a short distance in the interior, the winters are almost Arctic in severity.

The principal stream in the vicinity of Sitka, is the Stickeen; which rises in the "Blue Mountains," opposite the head-waters of the Mackenzie, and flows in a general southeasterly direction parallel with the coast until it breaks through the mountains east, and a little north, of Sitka. When the snows are melting, the river becomes much swollen and is then navigable with difficulty by small steamboats for about 125 miles above its mouth. The valley is generally narrow and the river is not bordered by a great breadth of alluvial land.

In ascending this river one glacier after another comes into view; all of them are upon the right bank of the stream and descend from the inner slope of the mountain range. There are four large glaciers and several smaller ones visible within a distance of 60 or 70 miles from the mouth.

The first glacier observed, fills a rocky gorge of rapid descent, about two miles from the river, and looks like an enormous cascade. The mountains are greatly eroded by it, for it is overhung by freshly broken cliffs of rock evidently produced by the glacier.

The second glacier is much larger, and has less inclination. It sweeps grandly out into the valley from an opening between high mountains from a source that is not visible. It ends at the level of the river in an irregular bluff of ice, a mile and a half or two miles in length, and about 150 feet high. Two or more terminal moraines protect it from the direct action of the stream. What

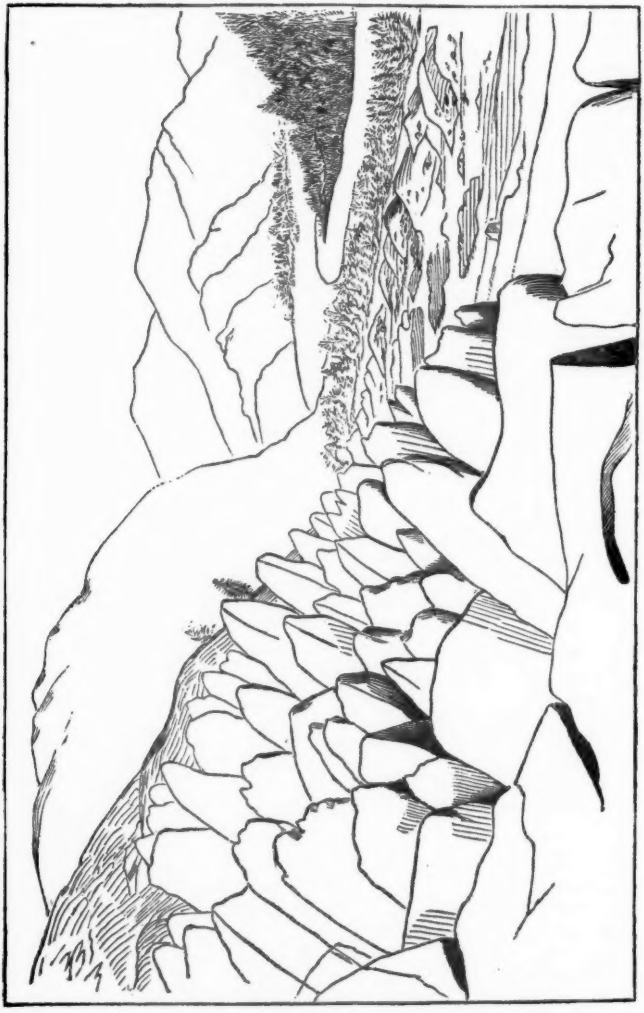
* The observations upon which this article is based were made in May, 1863, while a guest on his Imperial Russian Majesty's Corvette "Rynda," Commander Banarguine, by whose courtesy the writer accompanied Lt. Pereleshin on a reconnaissance, in a whale boat, of the Stickeen river, under the orders of Admiral Popoff. —W. P. B.

at first appeared as a range of ordinary hills along the river, proved on landing to be an ancient terminal moraine, crescent-shaped, and covered with a forest. It extends the full length of the front of the glacier. The following extract from my notes will answer for a description of the end of this glacier.

We found the bank composed of large angular blocks of granite mingled with smaller fragments and sand. It is an outer and older moraine, separated from a second one by a belt of marsh-land overgrown with alders and grass, and interspersed with ponds of water. Crossing this low space we clambered up the loose granitic debris of the inner moraine, which is quite bare of vegetation and has a recently formed appearance. These hills are from 20 to 40 feet high, and form a continuous line parallel with the outer and ancient moraine. From their tops we had a full view of the ice cliffs of the end of the glacier, rising before us like a wall, but separated from the moraine by a second belt of marsh and ponds. Here, however, there were no plants or trees. It was a scene of utter desolation. Great blocks of granite lay piled in confusion among heaps of sand or sand-cones or were perched upon narrow columns of ice-glacier tables apparently ready to topple over at the slightest touch. The edges of great masses of ice could be seen around pools of water, but most of the surface was hidden by a deposit of mud, gravel and broken rock. It was evident, however, that all this was upon a foundation of ice, for here and there it was uplifted, apparently, in great masses leaving chasms filled with mud and water. Over this fearful and dangerous place we crossed to the firmer and comparatively unbroken slope of ice at the foot of the bluff, and afterward had to climb over snow and ice only, in the attempt to reach the top of the glacier. From below it had appeared to us to be quite possible to accomplish this if we followed the least broken part of the slope, but it proved to be difficult, and finally impossible. Fissures which could not be seen from a short distance were met at intervals, some of them being so wide that we were forced to turn aside. As we ascended, the crevasses were more numerous but were generally filled with hard snow to which we occasionally trusted. The surface soon became precipitous and broken into irregular stair-like blocks with smooth sides and so large that it was impossible to make our way over them without ladders or tools to cut a foothold. Here we turned and enjoyed the sight of this great expanse of ice, broken into such enormous blocks and ledges. The sun illuminated the crevasses with the most beautiful aquamarine tints, passing into a deep sea-blue where they were narrow and deep. In one direction the ice presented the remarkable appearance of a succession of cones or pyramids with curved sides. In the oppo-

site direction and at the same level the outlines were totally different, showing merely a succession of terraces or steps inclined

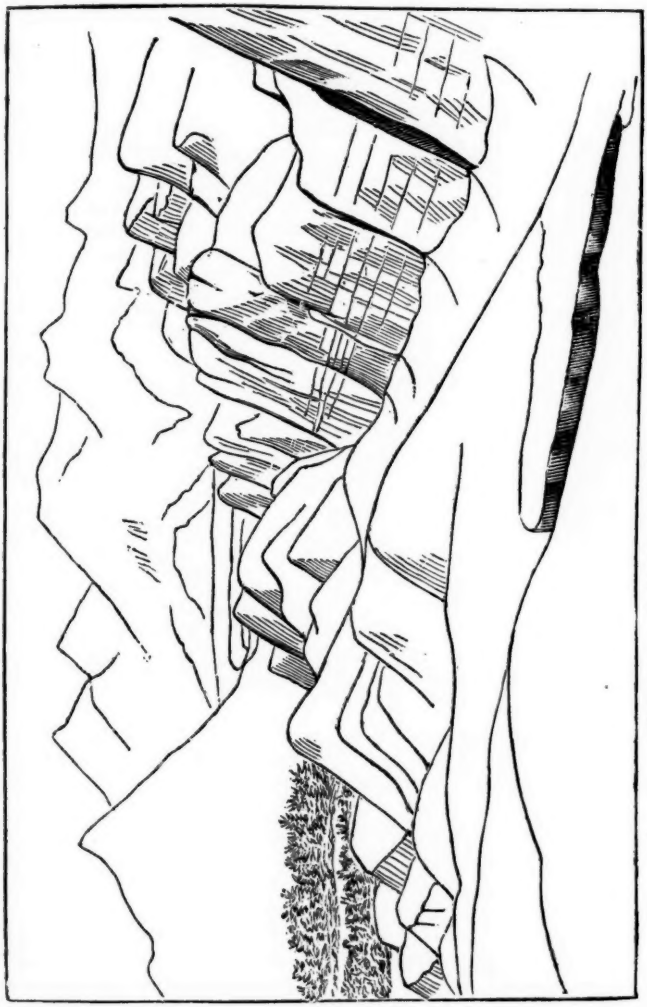
1.



inward toward the glacier and broken by longitudinal crevasses. The annexed sketches were made from this point of view. No. 1 is taken looking up the river, over the end of the glacier, and

shows the pyramids of ice. The line of ponds, and the two moraines are seen at the base, and the river on the extreme

2.

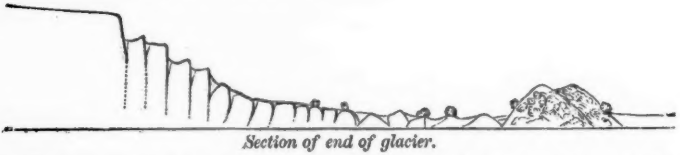


Bluffs of ice. End of Glacier, looking toward the southeast.

right. No. 2 shows the appearance of the glacier in the opposite direction. A broad fissure between one level of the ice and the next is filled with snow.

It is evident that this glacier breaks down in a series of great steps or ledges along the greater part of its front. These steps rise for 20 to 30 feet one above the other and thus produce a stair-like ascent, while at the same time the numerous parallel fissures at right angles break the surface into rectangular blocks, which on the side exposed to the sun soon become worn into the pyramids and cones. The difference of outline in opposite directions is thus explained.

I was inclined to regard the melting action of the water of the river as the cause of this abrupt breaking off of the end of the glacier. There may, however, be a sudden break in the rock foundations at this point, so as to produce an ice-cascade. The following section will perhaps give a clearer idea of the manner in which the glacier breaks down.



Section of end of glacier.

One or more streams descend under the glacier, and reach the river at different places. The rushing and roaring sound was rather startling at some of the crevasses.

Judging from the number of loose blocks of rock at the foot of the glacier, the upper surface must be strewn with them, but this could not be verified by observation. Time did not permit a more extended examination. There would be little difficulty in gaining the surface of the glacier from the side, and, perhaps, at some other points along its front. It was impossible to get our Indian guide to accompany us. They have a tradition of the loss of one of their chiefs upon this glacier.

The ancient terminal moraine of this glacier is significant of an amelioration of the climate. It is also interesting to note the effect which this accumulation of materials from the glacier has had upon the river. It has acted as a dam for the waters, setting them back in the valley for some distance.

In this connection the following notes upon the occurrence of great bodies of ice, undoubtedly glaciers, in the more northern parts of Russian America have a special interest.

According to Sir Edward Belcher* the shores of Icy Bay at the foot of Mount St. Elias, lat. 60°, are lined with glaciers. "The whole of this Bay, and the valley above it, was found to be composed of (apparently) snow-ice, about 30 feet in height at the water cliff, and probably based on a low muddy beach." At Cape Suckling in the same latitude and west of Icy Bay the

* Voyage of the Sulphur, i, 78–80.

same voyager observed a vast mass of ice sloping to the sea, the surface of which presented a most singular aspect, being "one mass of four-sided truncated pyramids." He was not able to account for this and observes "What could produce these special forms? If one could fancy himself perched on an eminence about 500 feet above a city of snow-white pyramidal houses, with smoke-colored flat roofs covering many square miles of surface and rising ridge above ridge in steps, he might form some faint idea of this beautiful freak of Nature."

Vast bodies of ice terminating in cliffs upon the sea are numerous in Prince William Sound, and the thundering noise of the falling of large masses of ice was heard by Vancouver.*

On the shores of an arm of Stephens Passage (northwest of Sitka) a compact body of ice extended for some distance at the time of Vancouver's visit, and from the rugged valleys in the mountains around, immense bodies of ice reached perpendicularly to the sea, so that boats could not land. Similar observations are made, in general, of the mountains of the coast opposite Admiralty island. Two large open bays north and west of Point Couverdeen are terminated by solid mountains of ice rising perpendicularly from the water's edge.

From these various observations we may conclude that the mountain region of Russian and British North America, from latitude 55° to the Polar sea, is dotted with glaciers cutting and scoring the mountains as they descend, and pushing their accumulations of rocky debris either into the ocean, or the rivers of the interior.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the influence of the adhesion of vapor in experiments upon the absorption of heat.*—The subject of the absorption of radiant heat by aqueous vapor has been again taken up by Magnus who has succeeded in pointing out the source of error which affected the experiments of Tyndall and of Wild.† In a previous memoir Magnus had endeavored to shew that vesicular vapor absorbs heat more powerfully than dry air, but that air loaded with transparent vapor has no greater absorptive power than air which contains no vapor at all. Tyndall replied to this paper, and the subject was then examined independently by Wild, who fully confirmed the results of Tyndall. In his new investigation Magnus employed an apparatus of the same dimensions with that of Wild and of similar construction. Experiment soon proved that the walls of the tubes containing the dry or moist air through which the radiant heat passed exercised a

* Vancouver's Voyages, iii, 185, (1794), quoted by Findlay, Directory of Pacific Ocean, i, 479.

† Pogg. Ann., cxxix, 57.

powerful influence upon the absorption. Thus a tube coated internally with lamp-black produced an effect precisely the opposite of that which was observed when a polished tube was employed. In this case an increase in the amount of heat transmitted was observed when moist air was blown into the tube and a diminution with dry air, while the contrary takes place when a polished tube is used. Magnus proved that a layer of water is deposited upon the inside of the tube throughout its whole length, by shewing that the tube itself becomes warmer whenever moist air is thrown in. This layer of water absorbs more heat than the polished wall of the tube would do if dry, and consequently reflects less to the thermo-electric pile. Experiment showed that the quantity of heat reflected to the pile by the dry wall of a polished brass tube filled with dry air was about six times as great as that which the pile received directly when the tube was removed. Every diminution in the reflecting power of the tube must therefore greatly diminish the quantity of heat received by the pile. In a blackened tube the particles of carbon act as absorbents like the particles of water, only in a higher degree, consequently their absorption is but little increased by the deposition of water.

Hence there is no sensible cooling when moist air is blown into a tube lined with velvet or blackened inside, but on the contrary a rise of temperature which depends on the heat given out by the condensation. By employing two concentric tubes the space between which could be filled with water at different temperatures, Magnus found that when the inner tube had exactly the temperature of the air blown into it, it behaved precisely like the brass tube mentioned above. When the temperature of the inner tube was a few degrees lower than that of the moist air thrown in, the temperature of the pile diminished in a very marked degree, but reached its minimum much more slowly than when the tube had the same temperature as the air thrown in. This doubtless arose from the fact that the greater quantity of condensed vapor made a greater quantity of moist air necessary, the admission of which required a longer time. Further experiments distinctly proved that a condensation of vapor upon the walls of the tube took place even when the moist air blown in was far from its point of saturation. The vapors of alcohol exhibited the same phenomena as those of water, only in a higher degree. In addition, however, it was found that the vapor of alcohol itself exerts a powerful absorbent action upon radiant heat, which is not the case with the vapor of water. The author concludes from his experiments, that the apparent absorption of heat by aqueous vapor observed by Tyndall and Wild is due simply to the effect of the condensation of water upon the sides of the containing tubes, and not to any specific absorptive power in the vapor itself.—*Pogg. Ann.*, cxxx, 207. W. G.

2. *On fluosalts of antimony and arsenic.*—Marignac has examined the action of fluohydric acid upon antimonic and arsenic acids and the corresponding salts. Antimonic acid dissolves in fluohydric acid and gives a fluorid which could not be obtained crystallized but which may be evaporated to a gummy consistency. This fluorid unites readily with alkaline fluorids to form crystalline salts, which are very soluble and more or less deliquescent, their solutions are not precipitated—at least at first—by acids, sulphuretted hydrogen, caustic alkalies, or carbonates. The crys-

talline salts may be kept without decomposition, but by repeated evaporation they pass into oxyfluoantimonates. The salt SbF_5KF is formed when the gummy antimonate of potash is dissolved in fluohydric acid and the solution evaporated. It crystallizes in thin anhydrous leaves. With an excess of fluorid of potassium this salt gives $SbF_5, 2KF+2H_2\Theta$ in beautiful very brilliant prisms derived from an oblique rhombic prism. A fluo-oxyantimonate of sodium $Sb\Theta F_3, NaF+H_2\Theta$ is obtained by adding carbonate of soda to a solution of fluorid of antimony in an excess of fluohydric acid and separates in small deliquescent hexagonal prisms. When this last salt is dissolved in fluohydric acid, another crystalline soda salt is obtained having the formula SbF_5, NaF. Two crystalline ammonium salts have respectively the formulas SbF_5, NH_4F and $2(SbF_5, 2NH_4F)+H_2\Theta$.

The fluo-arsenates are still more easily soluble than the fluo-antimonates and therefore more difficult to obtain pure. Marignac describes crystalline salts having respectively the formulas $2(AsF_5, KF)+H_2\Theta$; $As\Theta F_3, KF+H_2\Theta$; $AsF_5, 2KF+H_2\Theta$; and $As_2\Theta F_8, 4KF+3H_2\Theta$; which last is perhaps $As\Theta F_3, 2KF+AsF_5, 2KF+3H_2\Theta$.—*Zeitschrift für Chemie*, iii, 107. W. G.

[*Note.*—The salts described by Marignac are of special interest as showing the relationship of niobium and tantalum to the nitrogen group. A comparison of the formulas of the fluorine compounds of arsenic and antimony with those of niobium and tantalum already described in this Journal will remove any doubt as to the pentatomic character of the metals last named, and as to the natural group of elements to which they belong.—W. G.]

3. *Action of the hydracids upon ethers.*—Gal has shown that the action of the hydracids upon both simple and compound ethers, is precisely analogous to that which these acids exert upon the anhydrids, already published by him.

If we let *A* represent a negative or acid radical, and *B* a positive or alcoholic one, the formation of a compound ether may be expressed thus:

$$A\text{Cl}+\left.\begin{matrix}B\\H\end{matrix}\right\}\Theta=\left.\begin{matrix}B\\A\end{matrix}\right\}\Theta+\text{HCl}.$$

Now it is evident that the reaction in the inverse direction will be $\left.\begin{matrix}B\\A\end{matrix}\right\}\Theta+\text{HBr}=\left.\begin{matrix}A\\H\end{matrix}\right\}\Theta+B\text{Br}$: rather than $\left.\begin{matrix}B\\A\end{matrix}\right\}\Theta+\text{HBr}=\left.\begin{matrix}B\\H\end{matrix}\right\}\Theta+A\text{Br}$; since in the latter case we return to our starting point. To confirm this theoretic view, Gal undertook the present research.

In these experiments, hydrobromic acid was the acid generally used; and the compound ethers employed were those formed with methyl and ethyl, by the fatty acid series $\mathfrak{C}_n\text{H}_{2n}\Theta_2$; the aromatic acid series, $\mathfrak{C}_n\text{H}_{2n-8}\Theta_2$; the oxalic acid series, $\mathfrak{C}_n\text{H}_{2n-2}\Theta_4$; the carbonic acid series, $\mathfrak{C}_n\text{H}_{2n}\Theta_3$; and by nitric acid. The ether was saturated with hydrobromic acid gas, and exposed in a sealed tube, to an elevated temperature for some hours. And in every case the decomposition was found to take place according to the equation given above, methylic or ethylic bromid being produced, and the acid of the ether being set free.

On the alcohols, hydrobromic acid acts thus:—

$$\left.\begin{matrix}B\\H\end{matrix}\right\}\Theta+\text{HBr}=\left.\begin{matrix}H\\H\end{matrix}\right\}\Theta+B\text{Br},$$

showing that we may consider alcohols as compound ethers, in which hydrogen acts the part of a negative radical. With the simple ethers, if the hydrobromic acid be in excess we have:—

$$\left.\begin{matrix}B\\B\end{matrix}\right\}\Theta+(HBr)_2=\left.\begin{matrix}H\\H\end{matrix}\right\}\Theta+(BBr)_2,$$

but if the ether be in larger proportion, then

$$\left.\begin{matrix}B\\B\end{matrix}\right\}\Theta+HBr=\left.\begin{matrix}B\\H\end{matrix}\right\}\Theta+BBr.$$

The mercaptans give rise to two reactions. First we have

$$\left.\begin{matrix}B\\H\end{matrix}\right\}S+HBr=\left.\begin{matrix}H\\H\end{matrix}\right\}S+BBr,$$

and secondly $\left.\begin{matrix}B\\H\end{matrix}\right\}S+(BBr)_2=\left.\begin{matrix}B\\B\\B\\Br\end{matrix}\right\}S+HBr$. The simple sulphur ethers act similarly; the first reaction is $\left.\begin{matrix}B\\B\end{matrix}\right\}S+HBr=\left.\begin{matrix}B\\H\end{matrix}\right\}S+BBr$, the second $\left.\begin{matrix}B\\H\end{matrix}\right\}S+BBr=\left.\begin{matrix}B\\B\\B\\Br\end{matrix}\right\}S$, as Cahours has also shown.—*Ann. Ch. Phys.*, IV, x, 5.

4. *On new mixed acids.*—In a more recent paper, Gal has described some new mixed acids which he has produced. Reasoning from the well known fact that by the action of potassic hydrate upon monobromacetic acid, glycollic acid is formed, according to the equation

$$\left.\begin{matrix}\mathrm{C_2\widehat{H_2}Br\Theta}\\H\end{matrix}\right\}\Theta+\left.\begin{matrix}K\\H\end{matrix}\right\}\Theta=\left.\begin{matrix}\mathrm{C_2\widehat{H_2}(H\Theta)\Theta}\\H\end{matrix}\right\}\Theta+KBr,$$

(or, as is more clearly exhibited in Frankland's notation,

$$\left\{\begin{matrix}\mathrm{CH_2Br}\\\mathrm{C\Theta Ho}\end{matrix}\right.+KHo=\left\{\begin{matrix}\mathrm{CH_2Ho}\\\mathrm{C\Theta Ho}\end{matrix}\right.+KBr),—$$

the change being the substitution of Ho(=HΘ, hydryl) for Br,—Gal concluded that the similar univalent radical oxacetyl,* in potassic acetate, might be similarly exchanged. Though in the discovery of such mixed acids, Gal has been anticipated by Strecker, Wurtz and others, he has in the present research added several new ones to the list.

By heating to 100° C. in a sealed tube, an alcoholic solution of ethylic monobromacetate with potassic acetate, he obtained a liquid having a density about 1, whose boiling point was 180° C., and whose formula, as given by analysis, was $\mathrm{C_6H_{10}\Theta_4}$. When heated in a sealed tube with an alcoholic solution of potassic hydrate, it was decomposed, yielding potassic acetate and glycollate, and alcohol. If it be treated with solid potash, and distilled, acetic ether passes over, and potassic glycollate remains in the retort. From these reactions, Gal infers that the liquid above mentioned is the ether of an acid formed from glycollic acid by replacing its hydryl by the radical oxacetyl, and which he calls aceto-glycollic acid. Its formation is thus represented: $\left\{\begin{matrix}\mathrm{CH_2Br}\\\mathrm{C\Theta Eto}\end{matrix}\right.+\left\{\begin{matrix}\mathrm{CH_3}\\\mathrm{C\Theta Ko}\end{matrix}\right.=\left\{\begin{matrix}\mathrm{CH_2Aco}\\\mathrm{C\Theta Eto}\end{matrix}\right.+KBr.$

* Oxacetyl, Aco=($\mathrm{C_2H_3\Theta_2}$).

By alcoholic potash it breaks up thus:

$$\left\{\begin{matrix}\text{C}H_2\text{Aco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right. + (\text{KHo})_2 = \left\{\begin{matrix}\text{C}H_2\text{Ho}\\ \text{C}\Theta\text{Ko}\end{matrix}\right. + \left\{\begin{matrix}\text{C}H_3\\ \text{C}\Theta\text{Ko}\end{matrix}\right. + \left\{\begin{matrix}\text{C}H_3\\ \text{C}H_2\text{Ho}.\end{matrix}\right.$$

By solid potash as follows: $\left\{\begin{matrix}\text{C}H_2\text{Aco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right. + \text{KHo} = \left\{\begin{matrix}\text{C}H_2\text{Ho}\\ \text{C}\Theta\text{Ko}\end{matrix}\right. = \left\{\begin{matrix}\text{C}H_3\\ \text{C}\Theta\text{Eto}.\end{matrix}\right.$

The ordinary compound ethers when distilled with potash, produce alcohol, and a salt of the acid they contain; while these mixed-acid ethers yield either a salt and a more simple ether; or two salts and alcohol.

This view of its constitution, Gal proposed to confirm by submitting the new ether to the action of the hydracids according to the method given in the preceding section. He saturated therefore several grams of this aceto-glycollic ether with hydrobromic acid gas, and heated to 100° C. After repeating this process several times, the product was distilled on the water bath. The distillate was pure ethylic bromid. A viscous mass was left in the retort which upon examination proved to be a mixture of acetic and monobromacetic acids; the action of the hydracid being $\left\{\begin{matrix}\text{C}H_2\text{Aco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right. + (\text{HBr})_2 = \text{Et}\,\text{Br} + \left\{\begin{matrix}\text{C}H_2\text{Br}\\ \text{C}\Theta\text{Ho}\end{matrix}\right. + \left\{\begin{matrix}\text{C}H_3\\ \text{C}\Theta\text{Ho}\end{matrix}\right.$ in perfect accordance with the generalization above given.

Gal prepared also ethylic butyro-glycollate, $\left\{\begin{matrix}\text{C}H_2\text{Buo}\\ \text{C}\Theta\text{Eto}\end{matrix}\right.$, by treating potassic butyrate with ethylic monobromacetate; ethylic butyro-butyllactate (better butyro-oxybutyrate), $\left\{\begin{matrix}\text{C}\text{EtHBuo}\\ \text{C}\Theta\text{Eto}\end{matrix}\right.$; and ethylic aceto-oxybutyrate $\left\{\begin{matrix}\text{C}\text{EtHAco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right.$. The last is isomeric with butyro-glycollic ether, both containing $\text{C}_7\text{H}_{14}\text{O}_4$. The number of mixed acids which can thus be formed is, as Gal observes, very great; especially when not only the mono-brominated fatty acids, but also the di- and tribrominated bodies of this series are used as starting points.—*Bull. Soc. Ch.*, II, vii, 329, April, 1867.

5. *On some new compounds of silicon.*—In a series of researches upon silicon and its compounds, made some years ago by Wöhler and Buff, they obtained, by passing hydrochloric acid gas over crystallized silicon heated to a temperature just below redness, a very volatile liquid, boiling at 42° C. and yielding an inflammable vapor. This liquid was decomposed by water, with the production of a white substance, differing entirely from silica in its properties. To the volatile liquid these chemists gave the formula $\text{Si}_2\text{Cl}_3 + 2\text{HCl}$; and to the white body the corresponding formula $\text{Si}_2\text{O}_3 + 2\text{HO}$, (Si=21).* More recently, however, Wöhler assigned to these bodies the formulæ $\text{Si}_6\text{H}_4\text{Cl}_{10}$ and $\text{Si}_6\text{H}_4\text{O}_{10}$ respectively† (Si=14.) The authors observe that the above compounds may not have been absolutely pure when analyzed, and call upon chemists having more leisure to re-examine the whole subject.

This investigation has been undertaken by Friedel and Ladenburg. In the first place, they thought it improbable from theoretical considerations, that so volatile a body as the above chlorid should have so complicated a molecule; and from its method of preparation they inferred that

* Ann. Ch. Pharm., civ, 94. This Journal, II, xxv, 270, 1858.

† Ib., cxxvii, 257. This Journal, II, xxxvii, 120, 1864.

it might be silicic chlorid, in which an atom of hydrogen had replaced one of chlorine. If they could not separate the body in question from the silicic chlorid formed at the same time, by fractional distillation, they were prepared to convert both into ethers and thus to effect the separation.

The compound was prepared by Wöhler and Buff's method. And they found that by subjecting the crude material to a series of careful fractionings, a liquid was obtained whose boiling point was 34° C. instead of 42°, and which distilled entirely between 34° C. and 37·5°. As thus purified, the liquid possessed all the properties mentioned by Wöhler and Buff. Its vapor mixed with air detonated violently in contact with flame, giving a white cloud of silica. It was analyzed by placing a weighed quantity in a sealed bulb, introducing this into a tube containing dilute ammonia, sealing the tube, and breaking the bulb. After a short time the tube was opened, its contents poured into a platinum dish and evaporated to dryness on the water-bath. The residue was treated with water, filtered, ignited and weighed; and by subtracting from the entire weight, that of the glass of the bulb, that of the silica was obtained. In the filtrate the chlorine was determined as usual. The results lead to the formula $SiCl_3H$, (Si=28.) That this formula moreover, represents the size of the molecule was proved by the vapor density; experiment giving 4·64, while theory requires 4·69. The hypothesis of its composition is thus confirmed; and they showed farther that at ordinary temperatures chlorine transforms it into silicic chlorid, $SiCl_4$; while at a red heat hydrogen acts upon $SiCl_4$, converting a portion of it into $SiCl_3H$.

When this substance is mixed with absolute alcohol, a large quantity of hydrochloric acid gas is evolved, and the resulting liquid, when subjected to fractional distillation, yields two bodies, one of which boils between 134° and 137°, and the other at 165° C. The latter body is silicic ether; the former is an ether corresponding to the chlorid above described. Its analysis gives the formula $SiC_6H_{16}O_3$, from which the authors derive the constitutional formula $\left.\begin{matrix}(SiH)''' \\ (C_2H_5)_3\end{matrix}\right\}O_3$. When silicic chlorid $SiCl_4$ acts upon alcohol, it produces silicic ether $\left.\begin{matrix}Si \\ (C_2H_5)_4\end{matrix}\right\}O_4$, as is well known; consequently the new ether bears the same relation to the volatile chlorid, that silicic ether bears to silicic chlorid. It is a limpid liquid, with an agreeable odor, and insoluble in water, by which it is slowly decomposed. It is rather more inflammable than silicic ether, and differs from it by evolving hydrogen when treated with an alcoholic solution of ammonia.

The action of sodium upon this ether is quite remarkable. When first introduced, a slight evolution of gas is perceived, due probably to the trace of alcohol present, produced by the action of atmospheric moisture on the chlorid. But if the mixture be gently heated, there is a uniform evolution of gas which upon examination proved to be pure hydric silicid or siliciuretted hydrogen. After allowing the first portions of the gas to escape, it may be collected for analysis. This was effected by placing a measured quantity in a graduated bell over mercury, and then passing up a concentrated solution of potash. The evolution of gas commenced at once; and, when the action ceased the volume was measured. It was found to occupy four times the volume of the original gas, and to burn

with the pale flame characteristic of hydrogen. The action of the potash then is as follows: $(HK\Theta)_4+SiH_4=K_4SiO_4+H_8$, from which it appears that one half the hydrogen comes from the potassic hydrate, the other half from the silicid. As 2 vols. of the latter increase to 8 vols. in the above experiment, they evidently furnish 4 vols. of hydrogen; and since an atom of hydrogen occupies one volume, and a molecule of silicid 2 volumes, it is evident that each molecule of the latter contains 4 hydrogen atoms, and that its formula is SiH_4. This is the formula assigned to it by Wöhler and Buff, its original discoverers; though they never obtained it pure, but always mixed with free hydrogen. The liquid which results from the action of the sodium, is pure ethylic silicate. The sodium appears to take no part in the reaction, since it remains white and metallic, and does not diminish in weight. The formation of the hydric silicid may therefore be thus represented:

$$\left(\begin{matrix}(SiH)'''\\(C_2H_5)_3\end{matrix}\right\}\Theta_3\Big)_4=SiH_4+\left(\begin{matrix}Si\\(C_2H_5)_4\end{matrix}\right\}\Theta_4\Big)_3.$$

The gas thus obtained is not spontaneously inflammable, at the ordinary atmospheric temperature and pressure. But if into a small quantity of it confined in a tall jar over mercury,—so that the mercury column considerably lessens the pressure,—a few bubbles of air be passed, ignition takes place with deposition of silicon mixed with silica. In this respect the gas behaves like hydric phosphid; and the authors suggest that the hydrogen mixed with the SiH_4 of Wöhler and Buff, may be the cause of its spontaneous inflammability. A hot knife blade placed near the bubbles as they rise through the mercury, inflames them with a slight explosion.

Friedel and Ladenburg have also examined the white substance produced by the action of water on the inflammable chlorid. It was prepared by passing the vapor of this chlorid into water at zero. The product was washed with ice-cold water, dried, first in a vacuum over sulphuric acid, and then in an oil bath at 150° to 180° C. and analyzed. The results give the formula $Si_2H_2\Theta_3$, from which the authors derive the rational formula $\left.\begin{matrix}SiH\Theta\\SiH\Theta\end{matrix}\right\}\Theta$. Its production is expressed thus:

$$((SiH)Cl_3)_2+(H_2\Theta)_3=\left.\begin{matrix}SiH\Theta\\SiH\Theta\end{matrix}\right\}\Theta+(HCl)_6.$$

These researches confirm the opinion originally advanced by Wöhler that these compounds are analogous to organic bodies, and consequently prove the analogy of silicon and carbon. It will be noticed that the inflammable chlorid $(SiH)Cl_3$ is similar to chloroform $(CH)Cl_3$; that the compound $\left.\begin{matrix}(SiH)'''\\(C_2H_5)_3\end{matrix}\right\}\Theta_3$ corresponds precisely to the tribasic formic ether of Kay $\left.\begin{matrix}(CH)'''\\(C_2H_5)_3\end{matrix}\right\}\Theta_3$; that hydric silicid SiH_4, is analogous to hydric carbid CH_4; and that the body $\left.\begin{matrix}SiH\Theta\\SiH\Theta\end{matrix}\right\}\Theta$ is identical in structure with formic anhydrid $\left.\begin{matrix}CH\Theta\\CH\Theta\end{matrix}\right\}\Theta$. For this reason, Friedel and Ladenburg propose the name *silici-chloroform* for the first substance, *tribasic silici-formic ether* for the second, and *silici-formic anhydrid* for the last. The quadrivalence of silicon seems therefore as firmly established as that of carbon itself.—*Bull. Soc. Ch.*, II, vii, 322, April, 1867.

6. *Crystallization of graphitoidal silicon.*—Professor W. H. MILLER has examined some crystals of graphitoidal silicon, so called, which were received from Dr. Percy. They appeared to be oblique; but on measurement, they were found to be regular octahedrons, in which two parallel faces were much larger than the others; two other parallel faces were either too small to be observed or were altogether wanting. One of these scales had the faces of a twin octahedron. He concludes therefore, that there is no crystallographic reason for separating the graphitoidal from the ordinary octahedral variety of silicon.

He also considers it probable that graphitoidal boron, recently shown by Wöhler and Deville to be an aluminic borid, is tetragonal, as Sella has shown the adamantine boron to be. Sella views even the latter variety as a definite compound of boron with aluminum and carbon, mechanically mixed with pure boron.—*Phil. Mag.*, IV, xxxi, 397, May, 1866.

7. *Density of Ozone.*—At the meeting of the French Academy on the 6th of May, REGNAULT communicated a note from Soret of Geneva, upon the density of ozone. As previously determined by this chemist, the density of this substance obtained in absorption experiments, is one and a half times that of oxygen. He has now re-determined it by means of Graham's law of diffusion; i. e., the velocity of diffusion of a gas is inversely as the square root of its density. He ascertained the coefficient of diffusion of chlorine into oxygen and of ozone into oxygen. He found that in 45 minutes, for every cubic centimeter of chlorine contained in one of the two diffusion tubes, 0·227 of chlorine diffused into the upper tube, while for ozone, the quantity under the same circumstances was 0·271. Now the ratio ·227 : 271 = ·8382 : 1; and if we assume ozone to have one and a half times the density of oxygen, Graham's law would give us $\sqrt{35\cdot5} : \sqrt{24} = 1 : \cdot8222$, a remarkably close approximation, considering the difficulties of the method. We may therefore fairly regard the density of ozone as one and a half times that of oxygen; or 1·657 if air be taken as 1, and 24 if hydrogen be unity. While therefore the molecule of free oxygen contains two atoms, that of ozone contains three.—*The Laboratory*, i, 121, May 18, 1867.

9. *Adamantine anthracitic carbon.*—In the name of M. le Comte de Douhet, Dumas presented recently to the Academy of Sciences at Paris some nodules of mineral carbon, remarkable for their hardness. They were found by Douhet in the hands of a merchant, who supposed them to come from Brazil, but their origin and mode of occurrence are not certainly known. These nodules consist of irregularly concentric layers. When cut and polished on the lapidary's wheel, they acquire a surprising luster. Even in the thinnest fragments the mineral is opaque. Its density is 1·66. A preliminary analysis by Friedel showed the presence of 11 per cent of ash; thus raising the question whether the hardness is not due to foreign impurities. Dumas therefore examined purer fragments, and found the quantity of ash 4 per cent in two specimens; one being the crude material, the other the same after pulverization and washing. Hence the ash is uniformly distributed through the mass. Moreover this ash is neutral in its reactions, and neither scratches nor abrades glass. Two elementary analyses gave Dumas, as a mean, the following composition: carbon 97·5, hydrogen 0·5, oxygen 1·5, ash 0·5 = 100.

This it will be noticed is the composition of anthracite. In a subsequent letter to Les Mondes, M. le Comte de Douhet, thus describes the mineral: The nodules are globular, mammillated, consisting of concentric layers, and occasionally possessing a nearly perfect cleavage. Though fragile and brittle, the fragments will scratch not only the hardest gems, but also the diamond itself; though ordinary anthracite will not scratch even glass. When facets are cut upon it, this singular mineral refracts and disperses light with that white luster which is characteristic of the diamond; other and colored gems reflect light tinged with color; while the brilliance of the diamond is always white, even when it is itself colored. Prismatic colors appear only when the light is refracted in the interior of the crystal. This mineral, being opaque, cannot decompose light, though it actively disperses it. These properties of hardness and luster contrast strangely with the feeble density, anthracitic appearance, and composition of this substance.

At the next session of the Academy, Dumas read a note from Mène, calling attention to some specimens of carbon presenting a similar appearance, which he had obtained artificially by heating in the muffle of a cupel furnace for a long time the anthracite coal of Creuzot. It thus acquires a metallic luster, steel-gray color, and scratches glass and steel with the cry of the diamond. Its density is 1·637, and its composition is carbon 96·8, volatile matter 1·0, ash 2·2=100. Mène also states that the coke produced from a mixture of the Creuzot anthracite with the St. Etienne bituminous, contains a multitude of brilliant points which readily scratch glass.—*Comptes Rendus*, lxiv, 547 and 674; *Les Mondes*, Apr. 11, 1867.

10. *On the origin of meteorites.*—In his researches on diffusion, GRAHAM has shown that certain metals, such as iron, platinum, and gold, which occur native in the soft colloid condition, readily absorb or occlude gases. Hence by examination of the gases evolved from a meteorite for example, the character of the atmosphere through which the ignited mass has passed, may be determined. The well known Lenarto meteorite is admirably adapted for such an experiment, being very pure and soft. A piece 50 millimeters long, 13 wide and 10 thick, was cut from the mass, cleansed and placed in a porcelain tube connected with a Sprengel aspirator. The tube was then heated in an ordinary combustion furnace by ignited charcoal. Gas was freely evolved, which in 2½ hours amounted to 16·53 cubic centimeters. This gas burned like hydrogen, and when analyzed gave 85·68 hydrogen, 4·46 carbonic oxyd, 9·86 nitrogen in the 100. As the volume of the iron was 5·78 c.c., it appears to yield 2·85 times its volume of gas, of which 86 per cent is hydrogen. Now, since hydrogen has been shown by spectrum analysis to be present in the fixed stars, and by Secchi to be a principal element in some of them, we may fairly suppose that the Lenarto meteorite has brought to us the hydrogen of those distant bodies. Moreover it is found that malleable iron can scarcely be made to occlude more than its own volume of hydrogen under the ordinary atmospheric pressure. But the meteorite gave three times this quantity. Hence Graham infers that it must have originated beyond the limits of the light cometary matter of our solar system.—*Chem. News*, May 31, 1867.

11. *Action of manganic peroxyd on uric acid.*—C. GILBERT WHEELER finds that when uric acid is warmed with water and manganic peroxyd, and sulphuric acid added in small portions, so long as any action is observed, the filtrate yields on concentration, crystals of parabanic acid. But that if the mixture of water and uric acid be treated with the peroxyd so long as carbonic dioxyd is evolved, and the whole filtered, manganic oxalate is left on the filter, and the filtrate contains allantoin and urea. He gives the reaction as follows:

$(C_5H_4N_4O_3)_3+(MnO_2)_3+(H_2O)_4=(C_4H_6N_4O_3)_2+(COH_4N_2)_2+(MnC_2O_4)_2+MnCO_3$.—*From the author's paper in the Zeitschrift für Chemie.*

12. *Indium.*—Fremy exhibited to the Academy on the 22nd of April, in behalf of Professor Richter who was present, two ingots of indium obtained from the Freiberg blendes, which were about a decimeter high, and a few centimeters in diameter, and weighed 500 grams. They were valued at 20,000f.

13. *Expansion of metals and alloys by heat.*—A. MATTHIESSEN has applied the hydrostatic method—by means of which he determined the expansion of water and mercury (see this Journal, II, xliii, 254)—to metals and alloys. The unit of volume at 0° C. becomes at t° C.,

$$V_t=1+\frac{a}{10000}t+\frac{b}{1000000}t^2,$$

and is at 100° C. equal to $1+c$. The values of a, b, and c determined by him are as follows:

	a.	b.	c.
Cadmium,	0·8078	0·140	0·009478
Zinc,	·8222	·070	8928
Lead,	·8177	·0222	8399
Tin,	·6100	·0789	6889
Silver,	·5426	·0405	5831
Copper,	·4443	·0555	4998
Gold,	·4075	·0336	4411
Bismuth,	·3502	·0446	3948
Palladium,	·3032	·0280	3312
Antimony,	·2770	·0397	3167
Platinum,	·2554	·0104	2658

He investigated the following 19 alloys: 1. Sn_4Pb; 2. Pb_4Sn; 3. CdPb; 4. Sn_4Zn; 5. Sn_6Zn; 6. $Bi_{44}Sn$; 7. $BiSn_2$; 8. $Bi_{24}Pb$; 9. $BiPb_2$; 10. Cu+(33·85 vol.) Zn; 11. $AuSn_2$; 12. Au_2Sn_7; 13. Ag_4Au; 14. AgAu; 15. $AgAu_4$; 16. Ag+(19·65 vol.) Pt; 17. Cu+(48·06 vol.) Au; 18. Cu+(28·31 vol.) Ag; 19. Cu+(73·13 vol.) Ag.

The volume at 100° C. was determined as above and also calculated from that of the component metals; he obtained also the specific gravity, and in an earlier investigation the electric conductibility. The results thus obtained are:

No. of Alloy.	Volume at 100° C.		Specific gravity.		Conductibility.	
	Observed.	Calculated.	Observ.	Calc.	Observ.	Calc.
1.	1·007188	1·007225	8·188	8·203	10·57	10·63
2.	8419	8129	10·590	10·645	8·28	8·43
3.	9138	8847	10·246	10·246	12·61	13·72
4.	7184	7144	....	....	13·22	13·45
5.	7058	7066	....	....	12·66	12·84

No. of Alloy.	Volume at 100° C. Observed.	Calculated.	Specific gravity. Observ.	Calc.	Conductibility. Observ.	Calc.
6.	4064	3972	9·803	9·801	0·245	1·28
7.	5098	5207	8·772	8·738	3·96	5·59
8.	4086	4026	9·845	9·850	0·257	1·30
9.	8621	6007	10·956	10·541	2·09	4·23
10.	5719	6228	....	....	21·71	70·20
11.	4233	5919	11·833	11·978	14·27	35·51
12.	4428	6223	....	....	6·00	28·25
13.	5166	5549	12·257	12·215	20·93	94·62
14.	4916	5123	14·870	14·847	14·59	86·52
15.	4300	4693	17·540	17·493	20·91	78·38
16.	4568	5207	....	....	6·70	83·60
17.	4657	4716	....	....	12·00	83·25
18.	5436	5238	....	....	67·85	95·00
19.	5713	5607	....	....	63·00	98·20

The volume at 0° C. being 1. From these tables Matthiessen concludes that the volume (as well as the specific gravity) of any alloy between 0° and 100° C. nearly equals the mean of the volumes of the alloyed metals at the given temperature. In other words, neither volume nor specific gravity depends on the *chemical* nature of the alloy; while the last two columns show that the electric conductibility, not being simply the calculated mean, does depend on the chemical condition of the alloy. In his concluding remarks, Matthiessen states that he is able to calculate the conductibility of any alloy if it be considered as a "solidified solution of one metal in the other."—*Pogg. Annalen*, 1867, cxxx, 50–76; *Cosmos*, 1867, v, 160. G. H.

14. *Undulatory theory of heat.*—Babinet says that his theory, first published in 1838 is still new; we give the following extract from L'Institut, 1866, pp. 340–342.

The heat of a molecule is its vis-viva; two molecules are in caloric equilibrium when they possess the same vis-viva. In this condition they will, either at a distance or in contact exchange equal quantities of heat, and if placed in the same sphere, they will produce the same radiation.

If Θ represents the mass of a molecule of oxygen having a velocity v, and H and v', the same quantities for hydrogen; then these molecules have the same quantity of heat and the same temperature if

$$\Theta v^2 = \mathrm{H}v'^2.$$

As $\Theta = 16\mathrm{H}$, we have $v' = 4v$.

For any two atoms m and m' with the velocities v and v' we have likewise

$$mv^2 = m'v'^2.$$

At any other temperature these atoms are still in equilibrium if their new velocities of vibration u and u' fulfill

$$mu^2 = m'u'^2.$$

Consequently $mv^2 - mu^2 = m'v'^2 - m'u'^2$.

That is, the two atoms gain or lose the same quantities of heat between two given temperatures. Or in other words, *the specific heat of elementary atoms is constant*, which is the law of Dulong and Petit.

According to Babinet, all molecules, vibrating separately, have the same vis-viva and heat, independent of the state of aggregation of the body (solid, liquid or gaseous). Hence the *unit of heat*—or one *dynamic calory*—is the excess of vis-viva of any molecule at 1° C. above

that which it has at 0° C. At this temperature, 0°, the total quantity of vis-viva of the molecule is very nearly 1200 such units.

By *combining* two molecules so that they vibrate as one, Babinet proves that their vis-viva will be doubled; or if the final temperature is to be the original temperature, the combination must lose a vis-viva equal to that originally possessed by each of the molecules, or 1200 dynamic calories (?).

The demonstration of the law of Dulong and Petit is favorable to the peculiar views of Babinet; but we must await further developments before we can form an intelligent opinion concerning the other parts of his paper. G. H.

15. *Action of heat on the optical properties of crystals.*—DesCloizeaux has determined optically the system of crystallization for quite a number of minerals, hitherto imperfectly ascertained, and has also made some very important observations on the variation of the optical properties of crystals by heat. He finds:

(1.) On the optical properties of *uniaxial* crystals heat seems to have no influence. Crystals which, by some irregularity of structure, show an open cross (croix disloquée) resembling the hyperbolic branches of biaxial crystals, did not show any variation even by a change in temperature from 10° to 190° C. Anatase, apophyllite, beryl, idocrase, tourmaline, were among the crystals examined.

(2.) In *biaxial* crystals the apparent distance of the axes is generally changed by a change of temperature; so that the three indices of refraction are probably unequally modified by heat. Fizeau has shown by direct determinations that the indices of refraction of the ordinary and extraordinary rays in uniaxial calcite and quartz are thus unequally modified by heat. The amount of displacement of the axes, as well as the dispersion, are very different for different substances, but have not as yet been found related to other optical properties. DesCloizeaux found among 72 orthorhombic crystals—

		Displacement.	Dispersion.
19	showed	great,	great.
10	"	feeble,	considerable.
4	"	insensible,	considerable.
10	"	considerable,	feeble.
12	"	feeble,	very small.
17	"	insensible or uncertain,	very feeble or nearly zero.

Aragonite and the micas show exceedingly small variation. Celestine (increase of 6° 41′ between 10° and 105° C.) and leadhillite (diminution of 16° 50′ between 15° and 180°) are among the more variable.

(3.) While in the orthorhombic forms the median line of the optical axes remains unchanged, *it does change in most monoclinic crystals*, as already found by Neumann, in 1835, for gypsum. Among 22 such crystals with the optical axes in the plane of symmetry, and heated between 15° and 200° DesCloizeaux found that 11 showed a considerable, 6 showed a feeble or hardly sensible, 5 showed hardly any change in the median line.

(4.) The five triclinic minerals investigated (albite, amblygonite, axinite, disthene, sassoline) showed between 15° and 175° C. hardly any change in either the distance or the plane of their optical axes.—*L'Institut*, 1866, pp. 139–141. G. H.

16. *On the determination of atomic weights by optical means;* by Dr. ALBRECHT SCHRAUF.—If μ be the index of refraction and d the density of a body, then Newton's formula for the *refractive power* M of any substance is by Schrauf replaced by

$$M=\frac{A^2-1}{d}, \qquad N=\frac{B}{d^2}, \qquad \mu=A+\frac{B}{\lambda^2},$$

where λ is the wave-length, N the *dispersing power.*

Schrauf modifies the latter equation of Cauchy to $\mu=1+\frac{C'}{\lambda^2}$, where C′ is a constant, and uses A as the numerical value of μ for $\lambda=\lambda_\rho$, the wave-length of the red rays. For the correctness of this modified relation between μ and λ he gives good theoretical and experimental proof.

If P be the atomic weight of an element, then $\mathbf{M}=PM$ and $\mathbf{N}=PN$ are respectively what he calls the *refraction-* and *dispersion-equivalents.* Moreover, by considering light to be a vibratory motion of the atoms, he deduces $\mathbf{M}$ proportional to ZG,

where Z is the number and G the magnitude of the "physical atoms."

$\mathbf{M}$ of any element he determines by μ in the different conditions of aggregation, and also indirectly from the several compounds it forms. In the latter case he subtracts $\mathbf{M}$ (Pars) or the refraction-equivalent of the other parts from that of the substance entire, $\mathbf{M}$ (Tot);

$$\mathbf{M}\,(x)=\mathbf{M}\,(\text{Tot})-\mathbf{M}\,(\text{Pars}).$$

For any compound of a, b, c, etc., he puts

$$\mathbf{M}(a+b+c+\ldots)=n\mathbf{M}(a)+n'\mathbf{M}(b)+\text{ etc.},$$

where n, n' . . . are simple, entire numbers.

The following is a synopsis of the principal results. P are the *atomic* weights as now adopted.

Elements uncombined; μ directly determined.

Gas:	Hydrogen,	M=0·004050	$\mathbf{M}$=0·004050
	Oxygen,	0·000489	0·007824
	Nitrogen,	0·000602	0·008428
	Chlorine,	0·000627	0·022258
Liquid or solid:			
	Sulphur,	0·002044	0·065144
	Carbon, diamond,	0·001810	0·021720 etc.
μ determined by Brewster's law of polarization.			
	Antimony,	0·002545	0·30540
	Silver,	0·001262	0·13631
	Mercury,	0·001987	0·39740 etc.

Elements in combination:

Butyl-alcohol	$C_4H_{10}O$=74,	M=0·001474,	$\mathbf{M}$=0·109063
Ethyl-ether	$C_4H_{10}O$=74	0·001453	0·10757

Taking O as the part, and $x=C_4H_{10}$, the above-stated value of $\mathbf{M}(O)$ gives $\mathbf{M}(C_4H_{10}=\mathbf{M}(\text{tot.})-\mathbf{M}(\text{pars})=0{\cdot}100521.$

By means of this value he now from mercury-ethyl, $C_4H_{10}Hg$, calculates $\mathbf{M}(Hg)=0{\cdot}07598$, while direct determination from vapor gave

0·031800, and by means of Cauchy's formula for reflection from metals 0·021720, while by Brewster's formula 0·39740 was obtained. In this manner he determines the equivalent for quite a number of elements.

For easier comparison the refraction equivalents are referred to that of hydrogen as unity. These values he marks [**M**], hence for reduction

$$\mathbf{M}(H) : [\mathbf{M}(H)] = 0{\cdot}004050 : 1{\cdot}00.$$

Further he deduces from these latter values the *optical atomic numbers*, that of hydrogen being 100, by the equation

$$ZG = \frac{100}{P}[\mathbf{M}].$$

We condense Schrauf's tables into the following, giving the values of the atomic weight P (H=1), the refraction-equivalent [**M**] (also for H=1) and the optical atomic number ZG (that of H equal to 100). The last two refer to the *red* rays. The metallic, solid-liquid and gaseous states are indicated respectively by *m*, *f* (fest-flüssig) and *g*.*

	P		[M]	ZG		P		[M]	ZG
Hydrogen	1	*g*	1·00	100·00	Na	22	*f*	3·68	15·96
Al	27·4	*f*	5·79	21·14	P	31	*g*	4·81	15·51
Sb	120	*m*	75·59	62·99			*f*	18·70	60·31
As	75	*g*	4·05	5·23	Hg	200	*g*	7·87	3·83
		f	12·07	16·01			*f*	18·81	9·40†
Ba	137	*f*	11·38	8·30			*m*	98·38	49·19
Be	9·4	*f*	4·01	42·66	O	16	*g*	1·97	12·25
Pb	208	*f*	27·02	12·99	S	32	*g*	3·94	12·00
		m	88·60	42·60			*f*	16·13	50·40
Bo	22	*f*	9·18	41·71	Se	79·5	*m*	29·81	37·77
Br	80	*f*	10·76	13·45	Ag	108	*f*	9·08	8·40
Ca	40	*f*	6·65	16·65			*m*	33·75	31·25
Cd	112	*f*	11·61	10·38	Si	28	*f*	8·73	31·17
Cl	35·5	*g*	5·51	15·53		?	*m*	32·45	115·00
Fe	56	*m*	33·56	51·00	N	14	*g*	2·09	14·93
F	19	*f*	1·45	7·63	Sr	87·6	*f*	8·93	10·19
I	127	*f*	19·05	15·00	Ti	56	*f*	31·67	56·55
K	39·2	*f*	4·73	12·06	Bi	210	*f*	26·90	12·80
C	12	*f*	5·01	41·75			*m*	80·82	38·49
Cu	63·4	*f*	9·60	15·15	W	184	*f*	26·66	14·49
		m	17·83	27·05	Zn	65·2	*f*	7·23	10·93
Li	7	*f*	3·36	48·00			*m*	21·01	32·22
Mg	24	*f*	7·74	32·25	Sn	118	*f*	19·70	16·70
Mo	96	*f*	48·73	50·76	Zr	44·8	*f*	19·01	42·42

From this table Schrauf deduces further that the various conditions of the same elements are optically expressed in simple multiples. Thus for S as solid we have 16·13, which is 4 times 4·03, almost identical with 3·94 for sulphur vapor. Also that allied elements are optically in the same relation of simple multiples; thus the last column gives

F 7·63 (*f*), Br 13·45 (*f*), I 15·00 (*f*); Cl 15·53, *g*.
Θ 12·25 *g*; S 12·00 (*g*), Se (*m*) 37·77; S (*f*) 50·40;

so also N, As, P, Sb, Br, and other groups.

Though many points are yet obscure, we nevertheless hail this investigation of Schrauf as a decided progress.—*Ber. Ak. Wien*, lii, 176–211, 1865; *Pogg. Ann.*, cxxvii, 175–176, 1866. G. H.

* The symbols in the table, although none are written with barred letters, stand for the equivalents as adopted in the new system.

† By Cauchy's formula 8·96 and 4·48.

II. MINERALOGY AND GEOLOGY.

1. *Altitudes in British America.*—The following altitudes and localities of peaks, passes and stations in the Rocky Mountains in British America are compiled from the reports and maps of Capt. Palliser's explorations, published by Parliament, 1859–'65, and are given here for convenient reference. Some of the locations are taken from the observations published in the reports, others from the maps. When there is any discrepancy between the localities which have their latitudes and longitudes given in the earlier reports, and the maps, the latter have been followed, as they are the latest publications, and therefore may be inferred to be the more correct.

The altitudes are deduced from barometrical observations (aneroid), and the temperatures of boiling water.

	Latitude, North.	Longitude, West.	Altitude above sea.
	° ′	° ′	feet.
South Kootanie Pass,	49 10	114 55	6,030
British Kootanie Pass,	49 20	114 58	6,300
Kananaskis Pass,	50 40	115 25	5,700
Vermillion Pass,	51 12	116 10	4,903
Kicking-horse Pass,	51 24	117 25	5,210
Bow river Pass,	51 40	117	6,347
Pipe-stone river Pass,	51 40	116 30	7,200
Howe's Pass,	51 45	117 20	5,400
Otter Lake (source of the Columbia river),	50 07	116 5	3,090
Kootanie Trading Post (U. S.),	48 56	115	2,300
Fort Colville (U. S.),	48 38	118 3	1,050
Mt. Murchison,	51 47	117	13,500
Mt. Forbes,	51 45	117 36	13,400
Sullivan's Peak,	50 52	117 50	7,858
Mt. Tekarra,	52 50	118 40	
Mt. Brown,	52 28	118 25	
Mt. Hooker,	52 17	118 12	
Mt. Balfour,	51 35	117 10	
Mt. Vaux,	51 20	116 45	
Mt. Robinson,	50 52	115 27	
Mt. Head,	50 24	115	
Fort Carleton,	52 52	106 16	1,321
Fort Edmonton,	53 31	113 15	2,088
Old Bow Fort,	51 9	115 4	3,963
Rocky Mountain House,	52 40	115 10	3,195
Jasper House,	53 12	118 10	

"Kicking-horse Pass" is given here as located on the map; in the earliest report it is stated as long. 117° 20′ W., and alt. 5210 ft. (Rep. 1859, p. 38.)

Except Mt. Murchison, the heights named here are along the crest (watershed) of the Rocky Mountains; the names of other peaks were not added to this list, as no measurements are given. Mts. Brown and Hooker were stated by Douglass, many years ago, to be over 15,000 feet high, and on the map accompanying Sir Wm. Hooker's "*Flora Boreali-Americana*" (1840), Mt. Brown is stated to be 16,000 feet high, and Mt. Hooker 15,700 feet. In the first of Capt. Palliser's Reports (1859,

p. 39) he states of Mt. Murchison that "it is a most massive mountain, which the Indians consider to be the highest of all the Rocky Mountains. I afterward measured two of its highest peaks." * * "They are respectively 15,789 and 14,431 feet above the sea." This was written, however, at Fort Edmonton in Oct. 1858, and on the maps published in 1865, the altitude is given as tabulated above, 13,400 feet, probably as the result of later computations.

In the later and fuller Journal (1863, p. 112) speaking of it, he says, "if a rough triangulation I made of what I supposed to be the same peak from the Kootanie Plain, is to be trusted, it must be 13,000 to 14,000 feet above the sea. The average altitude of the mountains is 11,000 to 12,000 feet above the sea, and I do not place much reliance on estimates of altitudes greater than that, as there is a striking appearance of uniformity in the altitude of the mountains."

In this great mountain mass in which these peaks are, between lat. 51° and 53°, and long. 116° and 119°, the report speaks much of glaciers. About Mts. Lyell and Murchison especially they are on a grand scale, and descend into some of the valleys to an altitude of 4,320 feet above the sea, and fill great valleys above that altitude. All the conditions requisite for producing glaciers of great magnitude are stated to exist.

W. H. B.

2. *On some remains of Paleozoic Insects recently discovered in Nova Scotia and New Brunswick*; by J. W. Dawson, LL.D.—Dr. Dawson has communicated to us a paper with the above title from which we cite the following facts. Mr. James Barnes of Halifax has discovered in the shale of the coal formation, Little Glace Bay, Cape Breton, a wing of a Neuropter, whose full expanse of wing when alive must have been *seven inches*. Mr. Scudder has named it *Haplophebium Barnesii*, and pronounces it an *Ephemerina*. This is the second species thus far discovered in the Nova Scotia coal formation, the only other having been found by Dr. Dawson some years since in a Sigillaria stump, at the Joggins.

The remains of the Devonian insects described are the wings of four species found by Mr. C. F. Hartt in the plant-bearing Devonian shales of St. John, New Brunswick, probably equivalents of the Hamilton or Chemung formations of New York. The species are *Plutephemera antiqua* Scudder, of the *Ephemerina; Homothetus fossilis* Scudder, intermediate between the *Odontata* and *Sialina; Lithentomum Harttii* Scudder, approaching somewhat the *Hemeristina* of Illinois; *Xenoneura antiquorum* Scudder, another Neuropter, but the specimen is too imperfect to determine from it the family. Descriptions and wood-cuts of the wings by Mr. Scudder are given in the paper, which is to form part of the new edition of Dr. Dawson's Acadian Geology.

3. *A Monograph of the British Fossil Crustacea belonging to the order Merostomata*, Part I, *Pterygotus Anglicus*; by Henry Woodward, F.G.S., F.Z.S., of the British Museum. 44 pp. 4to, with 9 plates. From the publications of the Palæontographical Society, volume for 1865. London, 1866.—The Crustacean here described, from remains found in the lower Old Red Sandstone in Perthshire and Forfarshire, is one of the most remarkable fossils of the Paleozoic. As the author observes, the genus Pterygotus contains probably the largest species of the whole

Crustacean class. Four nearly entire bodies have been found, the largest about four feet long and fifteen inches broad, but with the head wanting. The memoir of Mr. Woodward is very full in its descriptions and its synonymy and references, and its illustrations are of natural size. The memoir opens with a table giving the arrangement and nomenclature of the segments of the Crustacea with their appendages; remarks on the classification of the order Merostomata; a table showing the geological range and geographical distribution of the species of the order; and the bibliography of the subject. Mr. Woodward has also published in the Quarterly Journal of the Geological Society for February, 1867, an illustrated paper on some points in the structure of the Xiphosura, having reference to their relationship with the Eurypteridæ.

4. *Observations on the Glacial Phenomena of Labrador and Maine, with a view of the recent Invertebrate Fauna of Labrador;* by A. S. PACKARD, Jr., M.D. Mem. Boston Soc. N. H., Vol. I. Published May, 1867. 92 pages quarto, with two plates.—In this important memoir the author brings together the evidence and materials bearing upon the nature of the marine deposits of the Post-tertiary or Drift period in Eastern North America. In the first part a description is given of the physical and geological features of eastern Labrador, with an account of the glacial phenomena which the author has observed there, and a catalogue of the fossils collected in the "Leda Clay" of Labrador and New Brunswick. This is followed by an account of the Glacial and Drift action in New England, with lists of the Leda Clay fossils from the various localities which have been examined.

The author recognizes four epochs or changes in physical conditions during the Post-tertiary or Quaternary Period. First, a period of elevation above the present sea level, accompanied by intense glacial action. Second, a period of subsidence, attended by an amelioration of the climate, during which the "Leda Clays" were deposited. Third, the *Period of raised Beaches*, during which the sea level was 500 or 600 feet higher than at present, while the climate had become warmer, allowing a northward migration of animals. Fourth, the *Terrace epoch*, during which the land was again elevated, causing the drainage of extensive estuaries and bays, and the formation of terraces.

From the character of the fossils of the Leda Clays at various localities it is shown that during this period the marine animals of the coast were distributed after nearly the same plan as at present, except that the Arctic and Sub-arctic faunæ descended a little farther along the coast, while the Virginian fauna even extended north of Cape Cod, its present limit,—the fossil shells of Point Shirley, Mass., agreeing with the existing species of Long Island Sound. At that period the Bison and the Walrus lived together in Maine, which had a marine fauna resembling that now found in Labrador and Newfoundland. The evidence is entirely opposed to the theory of a Tertiary or Post-tertiary connection of the land between Europe and America, and to any interchange of species either of animals or plants,—those that are common to the two continents being regarded as circumpolar species, which have descended to a greater or less extent on each continent during the cold period, and retreated or perished, more or less completely, during the subsequent warmer period. No change of

importance in the flow of the Gulf Stream could have occurred, as shown by the fossils of Point Shirley and Nantucket, but the arctic current swept more strongly against the coast of Maine and up the St. Lawrence river and Lake Champlain, and probably through the Bay of Fundy from the Gulf of St. Lawrence.

The second part of the paper is occupied by a Catalogue of the Marine Invertebrates of Labrador, in which a number of new species of Worms, Crustacea, and Mollusca are described. In the first part of the paper two new species of fossil shells are described from Labrador, viz., *Bela robusta* and *Fusus Labradorensis*, which, with numerous other interesting forms, are well figured. V.

5. *Exploring Expedition in the Interior Basin from Colorado west.*—The last Congress ordered an examination of a belt of territory on and near the 40th parallel of north latitude, between the meridians of 105° and 120° W., along and near the proposed route of the Pacific Rail Road. The survey is under the direction of the Secretary of War, or more immediately under Maj. Gen. A. A. Humphreys, chief of the U. S. Engineers, and Mr. Clarence King has been appointed to conduct the work, with the power to choose his own assistants. Mr. James T. Gardner is the first assistant in Topography, and Prof. James D. Hague in Geology. The party will consist of about ten scientific men, a few camp men, and a sufficient military escort for protection. The topography and geology of the country will receive the greater share of attention, but the other departments of science will not be neglected. A botanist, a zoologist, and a photographer accompany the expedition. The party sailed early in May for San Francisco, and will commence work as soon as possible at or near Pyramid Lake, and then work eastward.

The belt to be examined commences at the boundary of California, and extends entirely across Nevada and Utah, and into Colorado, to the eastern base of the Rocky Mountains. It is expected that when completed, and taken in connection with the labors of the State Geological Survey of California, and the private explorations of Prof. Whitney and Baron Richtofen in Nevada, it will furnish a geological section entirely across the great mountain system of the western part of the continent, at its widest portion, and include an examination of the most important formations producing the precious metals in North America. It is purposed to devote at least three years to the field-work.

Annexed is a list of the scientific corps as at present organized: Clarence King, chief in charge; James T. Gardner, H. Custer, and F. A. Clarke, Topographical assistants; Prof. J. D. Hague, Arnold Hague, and Samuel F. Emmons, Geological assistants; W. W. Bailey, Botanist, Robert Ridgeway, Zoologist, and T. H. O'Sullivan, Photographer.

6. *Locality of Secondary Fossils in Oregon;* by W. P. Blake, in a note to Prof. Dana, of June 1, 1867.—In my recent tour through Oregon I obtained a very interesting suite of fossils from Mr. Congdon at the Dalles, who collected or received them from Beaver creek and Crooked river south of John Day's, Oregon. There are *Trigonias*, apparently two species; a *Pholadomya*, *Ammonites*, *Fusus*, *Dentalium*, and a *Turrilites*, all of them very perfect casts of the inner and outer portions of the shell. The Turrilite indicates the Cretaceous age of the formation, and it is

possible that the other fossils may be referred to the same era instead of the Jurassic.

7. *Exogenous leaves in the Cretaceous rocks of Iowa;* by C. A. WHITE. From a letter to one of the editors, dated Nebraska City, June 6th, 1867. —While at Red Oak Junction, the county seat of Montgomery county, Mr. Meek found in the sandstone there, which I had called in my late article in the American Journal the "Nishnabotany sandstone," a couple of specimens of exogenous leaves which he says are identical with some of those described from the Lower Cretaceous of Nebraska. This is very satisfactory, since it confirms my previously expressed opinion; the place is the most southerly point at which undoubted Cretaceous rocks have been seen in Iowa.

8. *C. A. White on Drift Phenomena in S. W. Iowa.*—To the close of the first paragraph on page 303, vol. xliii, the following sentence should be added. "Sets No. 3 [on an accompanying map not published] represent a current coinciding quite nearly with the general direction of the drainage upon the western water-shed, and sets No. 1 and No. 2 represent currents approximately coinciding with the general courses of the Missouri and Platte rivers."

9. *On new localities of Diamonds in California.*—Prof. Silliman communicated through Mr. Goodyear the following facts to the Academy of Sciences of California at the meeting on May 7th. One diamond had been found in French Corral which weighed 5·114 grains (equal to $1\frac{1}{8}$ carats). It was symmetrical in form and slightly yellow in color from being subjected to a fire test. It was found in the deep gravel washings. The second specimen was from Forest Hill, El Dorado (Placer?) county; weight 5·673 grains, equal to nearly $1\frac{1}{2}$ carats; color good, but less perfect and symmetrical than the first. The third specimen was from Fiddletown, Amador county. It is smaller and less perfect than either of the others. Since 1855 five diamonds are known to have been found at Fiddletown, none weighing much over a carat. All were found in a gray, cemented gravel, underlying a stratum of lava or compact volcanic ashes. The fourth specimen was from Cherokee Flat, Butte county, which has acquired some reputation as a diamond locality. It has been cut and set in a ring.

10. *Note upon "Partzite;"* by WM. P. BLAKE.—The silver ore from Blind Springs, Mono county, California, described by Mr. Arents as a new mineral under the name Partzite (this Jour., xliii, 362), appears to be a mechanical mixture without a definite chemical composition. It evidently results from the decomposition of the antimonial and plumbiferous silver ores in the upper portions of the veins of that region. Specimens which I obtained there last year exhibit a variety of colors, and I do not think that analyses of any two different samples would agree.

11. *Reliquiæ Aquitanicæ; being Contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern France;* by EDOUARD LARTET and HENRY CHRISTY. Edited by Thomas Rupert Jones, Prof. Geol., etc., Roy. Military College, Sandhurst. Part IV, March, 1867, pages 25–32, and 57–72, Plates A. XIII, XIV; B. VII–X. (London, H. Baillière; Baillière Bros., New York).—This new number of the Reliquiæ Aquitanicæ opens with a brief statement of the charac-

teristics of the Reindeer period, and next takes up the features and geology of the valley of the Vezère. We cite the following paragraphs from Mr. Christy's observations on the Reindeer period.

"It would be easy to cite many circumstances illustrative of the resemblance between the condition and habits of the modern Esquimaux and these cave-dwellers of France at the Reindeer-period. But now comes the great question, When was the Reindeer-period in Southern France? and what is its antiquity?

"It is far easier to indicate its place in the series of observed facts in relation to ancient Man, than to assign to it any definite antiquity of years. Geologically, a wide gulf separates it from the Drift-period, though perhaps wider in the geological than in the paleontological aspect; but, on the other hand, it will seem, both from the paleontological and archæological bearings, to be of higher antiquity than the Kjökkenmöddings of Denmark and the Lacustrine Dwellings of Switzerland, and very certainly than the whole group of so called Celtic and Cromlech remains. Comparing its fauna with that of these various periods, the Reindeer-period may be placed thus:—

"In the Drift (Valley-gravels) the Mammoth, Rhinoceros, Horse, and Ox are the predominant animals, and the Reindeer appears but sparingly. In the Dordogne Caves the Reindeer predominates, associated largely with the Horse and Aurochs, and exceptionally with some remains of Mammoth, Hyena, &c.; but all traces of such domesticated animals as the Sheep, the Goat, and the Dog are wanting.

"In the Kjökkenmöddings of Denmark, though so much nearer the Subarctic regions, the Reindeer is not found, and the fauna, though more ancient than that now existing, indicates the presence of domesticated animals (Dog).

"The same may be said of the Swiss Lacustrine Dwellings: domestic animals are present; and the Reindeer is absent even from the most ancient of them, though that it was once in the neighborhood is manifested by the existence of its remains in caves (at l'Echelle) in the same district.

"In none of the Cromlechs or Sepulchres is there a trace of the Reindeer; and the fauna indicated by the remains found in them is cited as more recent than either the fauna of the Kjökkenmöddings or that of the most ancient of the lake-dwellings.

"From the archæological or industrial point of view, it may be remarked that from the Drift we have no example of Man's industry except implements of flint; and of these only the larger and coarser have been detected, though there is no reason to doubt that he had also implements for finer work than the majority of those found are fitted for.

"In the Reindeer-period, although Man had attained to a great proficiency in chipping, we have a total absence of ground or polished axes; and though he had arrived at the art of sewing, there is no trace of his having known how to spin; and in many of these caves of Dordogne there are no traces of pottery.

"In the Kjökkenmöddings pottery is not unfrequent, though ground axes are very few, but not wholly wanting, and spindle-whorls are scarce.

"In the very oldest of the lake-dwellings (those in which there is no trace of metal, as at Wangen) the majority of the axes are ground, and

the grinding-beds are the same as those found in the Surface-period of Denmark and England. Pottery is abundant; not only spinning but weaving is presented; and there are evidences that the cultivation of wheat and other cereals had been attained to. In the Cromlechs and the Sepulchres, pottery is abundant; and the frequent occurrence of articles in bronze indicates a later time.

12. *Manual of Geology;* by the Rev. SAMUEL HAUGHTON, M.D., F.R.S., Prof. Geol. Univ. of Dublin. 2nd ed., revised and considerably enlarged. 416 pp., 12mo. London, 1866. (Longmans, Green, Reader, and Dyer.) —Prof Haughton has aimed to present in his Manual the general results of geological investigation without many of its details. He commences at once with the origin of the globe, and presents deductions as to the successive steps of progress in its inorganic material and its life, throughout the history, illustrating this progress with many diagrams. While we could not subscribe to all of the deductions, thinking them often more positive than the facts warrant, we commend the book as one that will be read with profit. But it appears to us better for the teacher, to use in connection with his other works on the subject, than for the pupil. The author takes strong ground against the hypothesis of Lamarck and Darwin.

13. *On Species of Fossil Plants from the Tertiary of Mississippi*; by LEO LESQUEREUX. 24 pp., 4to, with 10 lithogr. plates. (From the Trans. Am. Phil. Soc., vol. xiii.)—A brief account of the plants here figured and described was given in the Geological report on Mississippi (1860) of Eug. W. Hilgard, by whom the specimens were collected. 22 species are described from the Red shale, making with 10 before described from Somerville, Tennessee (this Jour., II, xxvii, 363), 32 species; and 6 from the White soft clay of nearly the same age. They pertain to what Prof. Hilgard calls the North Lignitic group. One species, the *Calamopsis Danai* Lesq., is given in Dana's Geology, from a drawing furnished the author by Prof. Lesquereux. The other species are of the genera *Sabal, Salisburia, Populus, Salix, Quercus, Ficus, Laurus, Cinnamomum, Banksia, Persea, Ceanothus, Sapindus, Rhamnus, Juglans, Magnolia, Asimina, Phyllites.* Two of the plants of the genera Rhamnus and Phyllites are referred to living species, and the whole are pronounced by Lesquereux to have close relations to Miocene species. Yet he admits a resemblance to the Cretaceous plants of the Upper Missouri, and leaves the question of age unsolved for want of more data.

Prof. Lesquereux closes his memoir with descriptions of fossil leaves from the "Upper Cretaceous" of Fort Ellsworth, Nebraska.

14. *State Geological Survey of Iowa. Preliminary notice of New Genera and Species of Fossils;* by C. A. WHITE, M.D., State Geologist, and O. H. St.John, Assistant. 4 pp., 8vo.—Professor White mentions in this sheet, the occurrence of Protozoan shells of the genus *Amphistegina* in the Coal-measures of Iowa. He also describes the following species; *Aulosteges spondyliformis, Waldheimia compacta, Beyrichia lithofactor;* and the new genus *Meekella* to include as the typical species *Orthisina Missouriensis* Swallow (*Orthisina striato-costata* Cox), together with *Orthisina Shumardiana* Swallow, *Productus eximius* Eichwald, *Streptorhynchus occidentalis* and *S. pyramidalis* Newberry.

15. *Revue de Géologie pour les années*, 1864 et 1865, par M. DELESSE, Ingénieur en Chef des Mines, Prof. Géol., etc., et M. DE LAPPARENT, Ingénieur des Mines, Vice-Sec. Soc. Géol. de France. 279 pp., 8vo. Paris, 1866.—This annual is much like its predecessor noticed in volume xli. While not a complete review of the Geological papers of the years 1864, 1865, it contains much to interest all who would follow the progress of the Science of Geology.

III. BOTANY AND ZOOLOGY.

1. *Flora Orientalis, sive Enumeratio Plantarum in Oriente a Græcia et Egypto ad Indiæ fines hucusque observatarum;* auctore EDMOND BOISSIER. Vol. I, *Thalamiflore.* Basel and Geneva, 1867. pp. 1017, roy. 8vo.—We have just received this first volume of the flora of the Orient, with which, as is well known to botanists, Mr. Boissier has long been engaged. It is greatly needed, and will no doubt be ably and indefatigably carried on, we trust to an early completion. It connects the proper flora of Europe with that of Africa on the one hand, and of India and Siberia on the other; and covers the most interesting of all lands, Palestine and all Syria, Mesopotamia and Persia, Egypt and Greece. The preface briefly sketches the general characters of these regions, the botany of which is thus combined, notes the explorers who have made collections in any of them, from Rauwolf, Tournefort, and Wheeler down to the present time, indicates the districts in which he has himself botanized, and enumerates generally the sources of the various materials available for this work. He explains the plan of the publication, and the principles by which he is guided. He announces his conviction that species are direct creations as such, and fixed in character, variable more or less, but only within certain limits. To specific names he prefers to append the original authority for that name under whatever genus it may have fallen: e. g. "*Matthiola tristis* L. sub Cheirantho,"—although Linnæus, who had both genera, referred this species to *Cheiranthus.* In their orthography, he continues to write geographical adjective names with a capital initial, after the manner of DeCandolle, e. g., *Matthiola Arabica*, an usage which has never been universal, and from which in general there is a tendency to recede; while on the other hand, he writes proper substantive specific names with a small initial, e. g. *Ranunculus flammula*,—in which perhaps he stands nearly alone. Neither the species nor the genera are numbered. The name, specific character, and synonymy form one paragraph, the habitat another, in smaller type, descriptive notes or observations (when there are any) a third, and the geographical distribution, when wider than the limits of the work, is indicated in a fourth paragraph. Varieties also occupy separate paragraphs. The whole arrangement is very clear and convenient; but the type is so large and the page so open that the work will be more bulky than we should have thought expedient. Of its substantial excellence and conscientious accuracy there can be no doubt. A. G.

2. *Catalogue des Végétaux Ligneux du Canada, pour servir a l'Intelligence des Collections de bois économiques envoyées a l'Exposition Universelle de Paris*, 1867; par l'Abbé OVIDE BRUNET, etc. Quebec. 8vo

pamph., pp. 64.—Professor Brunet has brought out this convenient catalogue for the special purpose mentioned in the title; but it ought to be otherwise useful. He has not numbered the species, nor given their enumeration, so that we cannot without counting ascertain how many woody plants Canada can boast of. Plants so little woody as *Clematis Virginiana*, and even *Chiogenes*, and *Helianthemum Canadense* are included. But there is no mention of *Smilax*, nor of *Juniperus Sabina*, nor of the Red Spruce, nor Gray Oak, both probably mere varieties of other species, but worthy of examination by Canadian botanists. There are, also, two distinct kinds of Mountain Ash growing in the vicinity of Quebec, which Canadian botanists should notice.

Histoire des Picea qui se rencontrent dans les limites du Canada, is a smaller pamphlet by the same author, issued in 1866, with a plate of the two species, *P. alba* and *nigra*—the White and Black Spruce, and two photograph views of trees of the former. The glaucous-leaved variety of the Black Spruce, the common and almost the sole form of the species in Eastern New England, is named by Prof. Brunet, var. *grisea;* it is popularly called in Canada *Epinette Blanche*, or *Gray Spruce*. Spruce beer (made from Black Spruce), it appears, is an early invention. Prof. Brunet copies from Duhamel a curious account of the manner of making it more than a hundred years ago. A. G.

3. *Report of Proceedings of the International Horticultural Exhibition and Botanical Congress held in London, May* 22–31, 1866.—We reprinted at the time the masterly address of the President of this Botanical Congress, A. DeCandolle, and notices of most of the botanical papers read at the sessions, gathered from the abstracts published in the Gardeners' Chronicle. The Honorary Secretaries, Messrs. Moore, Hogg, and Masters, have how issued an official account of the whole proceedings, in a handsome royal 8vo volume of 428 pages, with plates, maps, &c. The volume is replete with interest, both horticultural and botanical. One of the most interesting articles is that of Dr. Masters on Double Flowers, which, did time and space allow, we should have been glad to present to our readers, in full or in abstract. A. G.

4. *Collections of Dried Plants of California* are often asked for, and may now be supplied. Mr. Bolander, who has formerly supplied some Grasses, &c., in this way, has now made up, from his recent collections in California, a dozen sets of beautiful and complete specimens of about 350 species of choice Californian plants; of which over one-third are *Cyperaceæ* (chiefly *Carex*) and *Gramineæ*, and more than a quarter *Compositæ*. The specimens will be named, according to the numbers. Sets can be had for $12 in currency per hundred, by making early application to Mr. Horace Mann, at Harvard University Herbarium, Cambridge. A. G.

5. *Growth of Lycoperdon giganteum;* by F. Moigno, in the Chem. News, Apr. 19, 1867.—The unexpected observation of the *Lycoperdon giganteum* has led M. Ernest Baudrimont to some very interesting conclusions. Fourteen days after its apparition at the surface of the ground it had acquired a considerable size. Plucked on September 17, 1866, when it commenced to decrease visibly, it was nearly of a regular spheroidal form, with a very short peduncle of a very beautiful white color, dull, and

slightly rosy; the skin was distended, and elastic under the pressure of the finger; its circumference measured 1m. 4c. on its greatest diameter, the weight being 3 kilo. 500 grams. When detached circularly by means of a sharp instrument, a great quantity of turbid liquid was disengaged of a greenish-yellow color. It was placed immediately in a baking-oven, where it remained twenty days. Taken out completely dried, it weighed 305 grams, thus showing that before desiccation it contained 91·28 per cent of water. Analysis has proved that nitrogen gas represented alone 8·96 per cent of the weight of the dried fungus, or 0·78 per cent of the weight of it in its normal state. If we suppose all this nitrogen to have been in the state of albumen, a substance which contains 17·70 per cent of nitrogen and 53 per cent of carbon, the total mass of lycoperdon (305 grams) contains 174·063 grams of carbon; we have even 142 grams by adding the carbon contained in the non-nitrogenized substances, its cellulose, &c. This being ascertained, we have 142 grams of carbon representing 520·66 grams, or 265 liters of carbonic acid, and thence 530,000 liters of air. It is from this enormous volume of air, which is about equal to a cube of 8 meters linear edge each way, that the fungus in question must have drawn, without losing a single trace, and, if we may so term it, with mathematical precision, the 142 grams of carbon necessary for its development of fourteen days. This is at the rate of, per day of twenty four hours, 10·15 grams of carbon, 18·9 liters of carbonic acid gas, and 37,800 liters of air. At 86,400 seconds per day, it is upon nearly half a liter of air that the plant must have operated per second to effect the total extraction of the carbonic acid gas which was in it. By what means can we estimate the prodigious activity that this inferior plant could develop to be able to take in fourteen days all the carbonic acid belonging to 530,000 liters of air? How astonishing, then, must be the delicacy of the absorptive organs which seize on its flight an elastic fluid—if we may so call it—intangible, disseminated in such an enormous mass, continually moving with great rapidity! But this is not all. The mean circumference of the fungus was 0·990 m.; the radius, 0·157 m.; its volume more than sixteen millions of cubic millimeters; and its mass formed of cellules 1 millimeter long at most, and the $\frac{1}{300}$th of a millimeter in thickness, between which are placed the reproductive spores. The total number of the cellules exceeds fourteen billions (14,589,140,400); and since the development lasted fourteen days, a million of cellules had to be produced every four hours—twelve thousand cellules per second! Just let one stroke of the pendulum, and then another, be heard, and conceive, if you can, that in that space of time the fungus constructed 12,000 cellules, besides (as the spores are a hundred times at least more numerous than the cellules) 1,200,000 spores, without any sensible shock or any hurried interior derangement capable of disturbing the mysterious equilibrium that reigns through all the parts of this living body. How great, then, is the prodigious energy which animates the material substance, and which can accommodate itself instantaneously to the exigencies of life!

6. *On the Parallelism between the different stages of Life in the Individual and those in the entire Group of the Molluscous Order Tetrabranchiata;* by Alpheus Hyatt. (From the Memoirs of the Boston Society of Natural History, vol. I.)—In this paper the remarkable changes, which

take place in the advanced period of life of an Ammonite by a process of degeneration or degradation of its structural character, are shown to have a singular analogy with the gradual decline in the characters of the genera and species just previous to the extinction of the order in geological times. The analogy of the process of decline in old age with that of development during the young state is also discussed, as well as the correspondence of the latter with the first appearance and gradual increase of the order in its geological history. V.

7. *Notes on the Radiata in the Museum of Yale College, with Descriptions of New Genera and Species;* by A. E. VERRILL. (From the Transactions of the Connecticut Academy of Arts and Sciences, Vol. I, Part II, 1867.)—*No.* 1. *Descriptions of New Starfishes from New Zealand.* Published March, 1867.—In this paper four new species of starfishes are described, two of which represent new genera, viz., *Cœlasterias australis*, *Coscinasterias muricata*, *Asterina regularis*, and *Astropecten Edwardsii*. The genus *Cœlasterias* is allied to *Asterias*, having four rows of suckers, but is multiradiate, with a large disk and large swollen arms. It has the aspect of *Solaster*. *Coscinasterias* is an allied genus, also with numerous rays, which are long and slender, arising from a comparatively small disk.

No. 2. *Notes on the Echinoderms of Panama and West Coast of America, with Descriptions of New Genera and Species.* Published, in part, March, 1867.* This paper embraces a complete review of all the Echinoderms, except Holothurians, contained in the Yale College Museum, from the west coast of Central and South America. Most of the materials are derived from the collections of Mr. F. H. Bradley, who has spent the past year on that coast. Sixty-eight species are enumerated, nearly all of which are described in detail, whether new or previously known. Twenty-two new species are included in this paper, together with four new genera. Among the more interesting new species are the following: *Astrophyton Panamense*, *Ophiura Daniana*, *Hemipholis gracilis*, *Ophiothela mirabilis* (new genus,) *Astropecten fragilis*, *A. Peruviana*, *Asterina modesta*, *Oreaster occidentalis*, *Mithrodia Bradleyi*, *Echinodiadema coronata* (new genus), *Astropyga venusta*, *Euryechinus imbecilis* (=E. gibbosus Val. ?), *Psammechinus pictus*, *Boletia viridis*, *Mellita Pacifica*, *Astroclypus Manni* (new genus), *Metalia nobilis*, *Brissus obesus*.

The name, *Ophiothela*, is proposed for peculiar, small, six-rayed Ophiurians allied to *Ophiothrix*, of which this group is made a sub-genus. *Echinodiadema* is allied to *Diadema* but has a spinose buccal membrane, trigeminate pores, and hollow spines. *Astroclypus* is allied to *Encope* and *Lobophora*. It differs from the first in having but four ovarial openings and in lacking the posterior perforation, and from *Lobophora* in having five ambulacral perforations, the position of the anus, etc.

Several changes in the nomenclature of known species are introduced, some of which are as follows: *Oreaster armatus* M. and Tr. is made a separate genus under Gray's subgeneric name, *Nidorellia; Echinocida-*

* The first part of this article embracing the *Ophiuroidea* and *Asteroidea* was printed and distributed in March and April; the remaining signatures, including the *Echinoidea*, etc., were not issued until June.

ris incisa A. Ag. (*E. longispina* Lutk.) is referred to *E. stellata* Ag.; *Boletia rosea* A. Ag. is referred to *Lytechinus*; *Encope tetrapora* Ag. (*non* Gm.) is redescribed under the new name, *E. occidentalis*; *Kleinia nigra* A. Ag. is referred to *Meoma* Gray; *Metalia* (Gray's subgenus of *Brissus*) is made identical with *Xanthobrissus* A. Ag. Four species of *Heliaster* are recognized.

The last part of the paper contains a discussion of the Geographical Distribution of the West Coast Echinoderms, with comparative lists of all the known species of various localities, and also a list of the West Indian and Aspinwall species for comparison with those of Panama.

8. *Remarkable Instances of Crustacean Parasitism*; by A. E. VERRILL.—In a collection of about ninety specimens of a small sea-urchin (*Eurychinus imbecillis* Verrill) from the coast of Peru, not one could be found in which the anal area and surrounding parts of the upper side of the shell were not more or less irregularly distorted, or imperfect. An examination of the interior showed that in each specimen a crab (*Fabia Chilensis* Dana), allied to the common crab of the oyster (*Pinnotheres ostreum*), had effected a lodgment in the upper part of the intestine, which had thereby been greatly distended in the form of a membranous cyst, attached to one side of the shell, and extending around to the lower surface near the mouth. The shell is usually swollen on the side over the cyst, and the anal area is depressed and distorted, with a large open orifice passing obliquely into the cyst, out of which the crab may thrust its legs at pleasure; but is apparently unable, when full grown, to come entirely out. All the specimens examined in the cyst were females, carrying eggs, but a very small crab found clinging among the spines appears to be the male. The crab probably effects an entrance into the intestine through the anus while quite young, and, by its presence and growth in that position, causes the gradual distortion of the shell and formation of the cyst. In Prof. Dana's Report on the Crustacea of the U. S. Expl. Expedition this crab is described as from Valparaiso, from an Echinus, but no special notice of its mode of occurrence and remarkable frequency appears to have been published.*

Another peculiar mode of parasitism I have observed in a singular crustacean (*Hapalocarcinus marsupialis* Stimpson†) from the Sandwich Islands. This creature lodges itself among the slender branches of a coral (*Pocillipora cæspitosa* Dana) and causes, probably by its incessant motions, the branches to grow up and surround it on both sides by flat expansions of coral, terminating in digitations, which often interlock above, leaving openings between them suitable for the uses of the parasite, but usually too small to allow of egress. Most specimens of the corals of this species sustain one or more, and often numerous, examples of these curious enlarged bulbs among the branches. The habits were unknown to Dr. Stimpson, when he described his specimens, which had dropped from among recently collected corals.

9. *On the external characters of the Young of the Central American Tapir* (*Elasmognathus Bairdii* Gill); by A. E. VERRILL.—This remarkable animal has hitherto been known only by its skull, and a skeleton, not

* *Pinnaxodis hirtipes* Heller, recently described fram Ecuador and found in an *Echinus*, is probably the same species.

† Proceedings Boston Soc. Nat. Hist., vi, 412.

entirely complete, belonging to the Smithsonian Institution. The Museum of Yale College has recently been so fortunate as to receive from J. H. Sternberg, Esq., a specimen of the young animal, preserved entire in alcohol. This individual is a female, and is supposed by Mr. Sternberg to have been about three months old in April. He states that its weight is not more than that of the head of the adult, one head that he formerly examined weighing 82 pounds.

Its entire length is 31 inches; nose to occiput 11; nose to eye 4·25; nose to incisor teeth 1·5; eye to ear 3·2; lower jaw 6·5; length of ear 3·5; breadth 2·5; tail from vent, not including hair, 2. The legs are short and stout. The tail small and inconspicuous. The head, viewed from the side, is elongated oval; from above elongated triangular, the sides nearly straight, the nose truncated. In advance of and above the eyes, the sides of the nose are compressed and concave, with a slight depression on its ridge. Beyond this the snout is enlarged, and convex both on the sides and above; the tip papillose and slightly decurved, which gives it a truncated appearance. The nostrils are large, oval, placed obliquely at the end of the nose, about half an inch long, the inner angles separated about a quarter inch, the margins thickened. The nose itself is quite flexible and, apparently, capable of extension. The ears are large and prominent, broad oval, rounded at the end. The hair is rather fine and soft, about an inch long on the body, and half as long on the head, where it is not so thick.

The general color is bright reddish-brown, the head darker above. The lips and end of the nose, bordering the naked, black tip, are white. Five interrupted narrow white stripes pass along each side of the nose, the upper one extending over and beyond the eye. The cheeks have several larger patches of whitish, one of which is under the eye; a larger white spot is on the throat. The ears are dark brown, lighter at the outer base, the tips, and several unequal spots on the outside, white. The back and sides are marked by longitudinal rows of yellowish-white patches, which partially blend into continuous stripes on the sides. There are in all about ten of these stripes. The under side of the body is uniform yellowish gray. The legs are darker brown than the body, and marked by numerous transverse bands and spots of white.

IV. ASTRONOMY.

1. *Prof. Adams upon the orbit of the November meteors.*—It was shown some time ago (this Journal, II, xxxviii, 57) that the periodic time of the November meteors must be one of five accurately determined periods. These five periods were 180·0 days, 185·4 days, 354·6 days, 376·6 days, and 33·25 years. The longitude of the node was also shown to increase with respect to the ecliptic 1′·711 in a year, which is equivalent to a procession with respect to the fixed stars of 29′ in a cycle of 33·25 years. It was also suggested that by computing the theoretical secular motion of the node for each one of the five possible orbits, and by comparing it with the observed motion we have an apparently simple means of deciding which of the five orbits is the true one.

Soon after the remarkable display of the meteors in November of last year, Prof. Adams undertook the examination of this question. Taking

first the orbit corresponding to a periodic time of 354·6 days, he found that the action of Jupiter produces an annual increase of the longitude of the node equal to 6″, and that of Venus an annual increase equal to 5″. The action of the earth was not so easily computed, owing to the intersection of the two orbits. An approximate solution applicable to this case showed, however, an annual increase of the longitude of the node of about 10″ due to this cause. The whole computed procession of the node was therefore about 21″ a year, or 12′ in the cycle of 33·25 years. The periodic time, 376·6 days, gives a result not widely different from the above, while in the two smaller orbits there would be a much smaller motion. Hence these four orbits, out of the five possible ones, are incompatible with the observed motion of the node.

Computing then the effect of the perturbing action of the planets upon the group, supposing it to have a periodic time of 33·25 years, Prof. Adams found that Jupiter increases the longitude of the node 20′ in one revolution, that Saturn increases it 7′, and Uranus increases it 1′. The other planets produce hardly any sensible effects, so that the entire calculated increase of the longitude of the node in the period of 33·25 years is about 28′. The observed increase during the same time is 29′. This remarkable accordance between the results of theory and observation appears to leave no doubt as to the correctness of the period of 33·25 years.

2. *Connection of Comets with Meteors.*—The remarkable relation between the Comets III 1862 and I 1866 and the August and November meteors naturally suggests a possible connection between other comets and other real or suspected meteor-showers.

Dr. Weiss of Vienna,* using a list of dates of star showers obtained from Humboldt, Quetelet, and Heis (overlooking the necessity of referring the showers to a fixed equinox), has computed the radius vectors of various comets at their two nodes, and finds the following coincidences. In the last column R − r is the earth's radius vector at the node, minus that of the comet. We give the whole table notwithstanding the fact that some of the showers are uncertain. The two dates in April belong to the same shower.

Date of shower.	Nodal passage.	Comet.	Node.	R − r.	
Jan. 1–4,	Jan. 3	II. 1792	♉	−0·073	
" "	" 4	IV. 1860	☊	+0·025	
Apr. 4–11,	Apr. 13	837	☊	−0·021	Very uncertain orbit.
" 20–24,	" 20	I. 1861	♉	0·002	
July 27–29,	July 27	II. 1737	♉	+0·005	
Sept. 18–25,	Sept. 17	I. 1790	♉	−0·054	Uncertain orbit.
" "	" 17	I. 1763	☊	−0·016	
Oct. 19–26,	Oct. 19	1779	☊	+0·024	
" "	" 20	1739	♉	−0·078	
" "	" 21	1097	♉	+0·056	
" "	" 24	1366	♉	−0·054	
Nov. 28,	Nov. 28	Biela's	♉	−0·018	
Dec. 6–9,	Dec. 9	IV. 1819	☊	+0·085	

The Comet II 1852, as well as III 1862, crosses the path of the earth on the 10th of August. Dr. Weiss suggests this as a cause of the want of definiteness of the August radiant, and of the duration of the shower.

* Astron. Nachr., No. 1632.

Prof. D'Arrest shows* that the meteors of the 6–7th of December have a radiant which is well represented by supposing them to have been formerly connected with Biela's comet. The longitude of the earth at the time (Dec. 6–7th) is 74°—75°, while the longitude of the node of Biela's comet from 1772 to 1832 was from 73° to 68°.

De Galle also shows† that the radiant for April 19–20th, which was given by Mr. Herrick as near α Lyræ in 1839, and which was found by Mr. Alex. S. Herschel to be at that point in 1864, differs only 7° from what would result from an orbit like that of comet I. 1861. This is within the possible error of observation.

The comet I. 1861 was discovered by Mr. A. E. Thatcher at Mr. Rutherfurd's observatory in New York City. At its brightest, it was equal to a star of the 2d or 3d magnitude.

Mr. Schiaparelli argues‡ that the mass of Uranus is so small that it is impossible for it to have turned the group of November meteors out of an orbit differing much from that described at present, without having at the same time entirely scattered the group. The perturbing body, which caused the change from a parabolic or a long elliptic orbit, is then either Jupiter or Saturn. It seems, therefore, to be necessary to reject the hypothesis of LeVerrier, that the great perturbation of the stream was due to Uranus and occurred in the year 126 of the Christian era.

Mr. Faye has presented to the Paris Academy of Sciences a hypothesis which connects the shooting stars, the zodiacal light, the rays of the corona seen in a solar eclipse, and the resisting medium which is believed to shorten the time of Encke's Comet, with the matter which is seen to flow from the nuclei of comets, forming their comas and tails. H. A. N.

3. *Observations of Shooting Stars, May 12th*, 1867.—It was thought that if the period of the November meteors was 354·6 days, we should probably meet a few straggling members of the group at the ascending node of their orbit, that is, on the 12th of May, 1867. The denser portion of the group of meteors would in six months, perhaps, have passed beyond the node. But if no stray members were to be seen *going toward Leo*, the evidence, though negative, would confirm the 33¼ year period. Accordingly, at Chicago, at Williamstown, at Olivet, and at New Haven, a watch was kept on that morning.

At Chicago, Mr. Francis Bradley, between a quarter before two and half past three o'clock saw but nine shooting stars, of which only two reminded him of the November meteors. Even the paths of these, as described in his letter, could not be regarded as going directly toward Leo.

At Williamstown, Mass., Mr. Leavitt saw 18 meteors between $1^h\ 50^m$ and $3^h\ 40^m$, five of which were noticeable as leaving the white train characteristic of November meteors. The paths of two of these are given in his letter. If produced they would pass a moderate distance from the Sickle.

At Olivet, Mich., Prof. Hewitt and Mr. Gaines, between $1^h\ 45^m$ and $3^h\ 15^m$, saw 28 shooting stars. There seemed to be a tendency to radiate from a region north of Aquarius, between that constellation and Pegasus.

* Astron. Nachr., No. 1633. † Ibid, No. 1635.

‡ Les Mondes, xiii, 501, March 28, 1867.

On the same morning, in the hour between 2^h and 3^h, A. M., Mr. A. Van Name, Mr. O. Harger, and the writer, saw at New Haven 34 meteors, most of them small ones. Only three or four of these were regarded as going toward Leo. These did not present in their physical appearance resemblances to the November meteors.

The result of the whole of the observations on this evening was to confirm the $33\frac{1}{4}$ year period. Since that time the remarkable results of Prof. Adams's computations have been received, which leave no longer the possibility of a doubt as to the true period. H. A. N.

4. *Elements of Comet* III, 1862.—Dr. Oppolzer of Vienna, has given in the Astronomische Nachrichten, No. 1638, the following corrected elements of the Comet III, 1862, which is connected with the August group of meteors.

Osculation: 1862, Aug. 23·0

T	=	Aug. 22·947139 Berlin m. t.	
π	=	290° 12′ 47″·84	mean equinox 1862·0
Ω	=	137 27 10 ·02	
i	=	113 34 12 ·24	
log q	=	9·9834650	
e	=	0·9607588	
log a	=	1·3897227	
per. time	=	121·502 years.	

Schiaparelli suggests a period of 108 years for the August meteors, the suggestion being based upon the following dates of star showers, from Quetelet's and Biot's catalogues; viz., 830, 833, 835, 841, 925, 926, 933, 1029, 1243, 1451, 1779, 1784, 1789.

A period of 108 years is however regarded by Dr. Oppolzer as incompatible with the observations, unless by allowances of errors which are altogether improbable. Planetary perturbations play a small part, it is believed, in the theory of this stream, as an exact determination of its period will doubtless show that it does not come near any planet except the earth.

5. *Comet* II, 1867.—A faint comet was discovered by Mr. Tempel at Marseilles on the third of April, 1867.

6. *Division of Biela's Comet.*—Prof. Bruhns of Leipsic, notices the fact* that at the time of the discovery of the division of Biela's comet it was crossing the path of the November stream. It seems hardly possible, however, that the density of the stream could have been sufficient, at that time and place, to have accomplished the separation.

7. *The Moon-crater "Linné."*—In the center of the bright spot which covers the former crater "Linné," there appears a minute black point, indicating a crater of about 600 yards diameter. The original crater appears to have been a deep one, and about 10,000 yards in diameter. This small crater was so plainly visible as to have been noticed (independently as it would seem) by Dr. Schmidt at Athens, by P. Secchi at Rome, and by Prof. Lyman at New Haven. It was detected here three days after the sun had risen over the horizon of "Linné," and when the sun was therefore 30° or 35° high upon it. These observations show that any change which has taken place is not in the nature of a development

* Astron. Nachr., No. 1631.

of a cloud, but imply rather that the old crater has been filled up by an eruption from the small one now visible.

According to Prof. Respighi of Rome, the western margin of the small crater in "Linné" is higher than the eastern, and was even visible as a bright point just before the sun rose upon the crater. He thinks that the historical evidence is not sufficient, however, to prove beyond doubt that a change has taken place.

Dr. Schmidt states that numerous and careful observations made during the four lunations, both in the waxing and in the waning moon, prove that "Linné" under no direction of the sun's light can now be seen as a normal crater.

Mr. Flammarion at Paris, observing carefully the place of "Linné" immediately after the rising of the sun upon it, could not detect the least shadow either within or without the position of the former crater. The fact that the height of the mountain was never given by the earlier observers he adduces as proof that it did not then have great altitude above the surrounding plain. Watching the place of "Linné" before the sun rose upon it he saw no light.

8. *Der Meteorsteinfall am 9 Juni, 1866, bei Knyahinya (zweiter Bericht);* von W. RITTER v. HAIDINGER. 48 pp., 8vo, with 3 plates; from the Berichte Akad. Wien., liv, Oct. 1866.—Haidinger here gives additional testimony with regard to the meteorite which was seen to fall a year since, in Hungary, 25 geographical miles N.N.E. of Unghvár, and 6 N.N.E. of Nagy Berezna. The remarkable facts and appearance attending the movement and fall are fully described from communications by many eye-witnesses, and illustrated with colored figures. The whole weight of the pieces that fell was about 900 pounds, and one piece is stated to have a weight of 550 pounds (Austrian). The memoir gives the exact geographical positions of the principal observers and discusses the movements of the meteor.

Haidinger, whose contributions to the department of meteorites have far exceeded in number and value all those of other contributors, and who has now become a veteran among philosophers, observes in a note accompanying the copy of the above mentioned memoir, that, while thus laboring for the progress of the science, he has never made any collections of meteorites for himself; and he now appeals frankly to the generosity of those who have made such collections for "such one or another fragment of meteorites or meteoric irons, as they may have at hand for disposal." He adds "I ask this as a free gift, to be received by me without any substantial retribution or equivalent, excepting the most cordial thanks for such great proofs of a liberal heart." Such gifts as he thus solicits are due to the liberal-hearted Haidinger. We rejoice to learn that he has been "honorably placed in retirement" by the Emperor as director of the I. R. Geological Institute of the Austrian Empire.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Earthquake in Kansas.* (1.) Notice of the earthquake by Wm. H. R. Lykins, from a letter to the editors, dated Lawrence, Kansas, April 25, 1867.—Yesterday the 24th of April, at 3 P. M., this locality was visited by an earthquake quite severe for this latitude. It was accompanied by the usual loud rumbling noise similar to that caused by the passing of half a dozen heavy omnibuses. The earth did not seem to rise or rock, but to tremble or vibrate. No dust was raised nor was there any unusual atmospheric disturbance perceptible; the weather being clear and cool. Doors and windows were violently shaken, type thrown down in printing offices, bottles shaken off druggists' shelves, plaster broken off, and in some instances walls slightly cracked. Persons out of doors did not feel any movement of the ground, but could see the buildings tremble. A butcher informed me his spring balance was drawn down a pound and a half by the shock. It commenced with a slight trembling, gradually increasing to its maximum and then gradually dying away; lasting, as near as I could judge, about thirty seconds, though some estimate its duration at one and a half minutes. Some professed to have felt three distinct shocks, but the majority described it as a gradually increasing and decreasing vibration. The same shock was felt simultaneously one hundred miles west and north of us; from places farther than this we have no information.

(2.) Notice of the earthquake by Prof. Wm. G. Williams, from a letter to the editors, dated Marysville, Marshall County, Kansas, April 25th, 1867.—At two o'clock and thirty minutes yesterday afternoon the shock of an earthquake was felt probably in every house and place of business in and near town. It was accompanied by the usual rumbling sound, and lasted a time variously estimated from one to three minutes.

No serious injury was done to persons, or property, beyond a temporary alarm on the part of a few. In stores, bottles and packages were made to rattle and in some cases were shaken from the shelves and broken. Windows, doors, shutters, stove-pipes and all loose or hanging articles, rattled, waved, or swung back and forth fearfully.

In several instances persons in the second stories of stores and houses, hearing the noise, and seeing and feeling the unwonted motions, ran down to stop the supposed disorder and tumult below, while those below ran up to stop that above. One lady knowing it to be an earthquake seized her infant child and hastened down stairs with a view to get out of doors for safety. A gentleman fishing in Spring Creek near town was leaning against a tree, feeling it shake and looking up, he saw it and other trees trembling and moving as if agitated by wind, although no breath of air was stirring. With my assistant teacher and some seventy scholars I was in the second story of our High School edifice. It is of stone and high pitched. The whole structure, desks, stove-pipes and other furniture were much shaken. The rumbling noises below much resembled those of heavy trunks on plank floors. I have had no opportunity to learn how extensively the shock was felt.

2. *On former changes in the Aral Sea;* by H. C. RAWLINSON, (from Proc. Roy. Geogr. Soc., March 11, 1867.)—There were certain points connected with the rivers Oxus and Jaxartes which he proposed to bring prominently before the meeting. They referred to a physical phenomenon which he believed was without parallel in the rest of the world, being, indeed, neither more nor less than the drying up at certain periods of history of the Sea of Aral, and its consequent disappearance from the map of Asia. The Aral, in terrestrial geography, might be compared with one of the variable stars in astronomy. As there were stars varying from the first to the fifth magnitude, so the Aral was at times a great inland sea 300 or 400 miles in length, at other times a mere reedy marsh, and even, occasionally, a hard desert land, so that travellers actually passed across it without being aware that they were travelling over the bed of a sea. Humboldt had devoted 200 pages of his famous work 'Asie Centrale' to the discussion of the geography of the Aral and the Caspian, and he had established beyond dispute that the Oxus had a variable course, sometimes falling into one sea and sometimes into the other; but he had not ventured to assert that the Aral ever disappeared altogether. Nevertheless, he (the Chairman) maintained that we had direct evidence of the fact in modern times, and he thought we had a right to assume its occurrence in ancient times.

The argument was briefly as follows: In all classical antiquity, from the earliest date, say from 600 years B.C. to 500 or 600 years after Christ —the Sea of Aral was utterly unknown in geography. There was not one single authority—Greek, Latin, or native Persian—who mentioned it. The two great rivers, the Oxus and the Jaxartes, which, by their contributions now form that sea, were described by all authors as falling into the Caspian. It must be remembered, too, that Alexander the Great conducted an army into that part of Asia, and employed officers for the express purpose of ascertaining the geographical configuration of the neighboring countries. He sent his troops on an expedition along the shores of the Caspian, while he in person crossed the Oxus, and reached the banks of the Jaxartes. Hence he must have possessed accurate information as to those localities, and yet the account which his officers brought back to Greece was that both the rivers fell into the Caspian. This statement, indeed, was adhered to throughout antiquity, and a practical proof was given of its truth in the notice of the line of commerce which supplied Europe with the products of Asia. This commercial route was described as starting from the foot of the Indian Caucasus, following the Oxus down to the Caspian, ascending the Kur or Cyrus, and descending the Phasis into the Black Sea, and thence crossing into Europe. We had thus direct evidence, as it seemed, that in the days when this route was followed and described, the Oxus must have fallen into the Caspian.

The Chairman went on to say, that as the present Sea of Aral filled an inconsiderable depression in the table-land of Central Asia, having no springs, and being entirely dependent for its supply on the two great rivers already mentioned, so it followed that if those rivers at any time were diverted from the Aral, the sea would necessarily become desiccated in a very few years, and the bed of it would revert to its original condition of a mere depression in the desert. The levels were a very important element in considering this question. That of the Aral was 117 feet

above the level of the Caspian, and 33 feet above the Black Sea, the Caspian itself being 84 feet below the Black Sea; so that if a communication were formed between the Aral and the Caspian, the Aral would naturally drain off into the lower basin. To proceed, however, with the argument. If, in the times of classic antiquity, there was a unanimity of evidence that the Oxus and Jaxartes flowed into the Caspian, so, from the beginning of the Mohammedan era, say from the year 600 to about 1300, or for a period of seven hundred years, there was an equal unanimity exactly the other way. During this period the Arabs and their political successors were in possession of the country. They were a literary and scientific people, and wrote numerous works on geography. They possessed the means of ascertaining full topographical details, and they invariably represented the two rivers as falling into the Sea of Aral, or the Lake of Kharesm, as it was then usually called. The only reasonable inference then seemed to be, that between the years 500 and 600 the course of the two rivers, owing to some natural disturbance, must have changed, and that, instead of continuing to fall into the Caspian, they became diverted into the sea of Aral, themselves, in fact forming that sea. Now came the most curious part of the question. From about the year A. D. 1300 to 1500, that is, for about 200 years, Europeans possessed means of becoming acquainted with the geography of Central Asia which had never been equalled up to the present day; for there were at that time frequent missions sent from the courts of Europe to Mongolia in Central Asia, and the ambassadors so employed had for the most part preserved records of their journeys. Colonel Yule, an associate of the Geographical Society, had recently brought a general summary of those records before the notice of the public in a most interesting work ('Cathay and the Way Thither'), of which he (the Chairman) could not speak too highly, and which he could not too strongly recommend to the notice of all lovers of geographical science. Colonel Yule's book contained records of many travels across Central Asia during the 13th and 14th centuries, and in not one of those records was the Aral mentioned, although the route of the travellers lay in most cases exactly across it. One of the authors in question, named Pegoletti, gave all the details of the commercial route at that time, which conducted from the Black Sea to China, and along which merchants conveyed the luxuries of Europe, and returned with the tea and silk of China. There were, indeed, detailed notices of the route in question, not only in the itineraries of Pegoletti, but in the maps which were constructed from memoranda furnished by travellers between the 13th and 16th centuries. One of these was called the Catalan Map; another was a map preserved in the Palatino Library at Florence; another was the Borgian Map, and the most famous of all was the Venetian map of Saint Mauro; and in none of these was the Aral noticed. The travellers came in the first instance from the Volga to Sarachak, on the eastern shore of the Caspian; and from thence they passed to Otrar, on the Jaxartes, the route lying across the bed of the Aral, which, nevertheless, in no single instance was either mentioned in the itineraries or laid down in the maps. On these negative grounds alone he should consider it quite certain that at that time the Aral did not exist; but we had fortunately positive evidence to confirm that conclusion.

Probably some of those present had heard of a very famous man called

Yar Mahomed Khan, who was chief of Herat during the period of the Afghan war about twenty-five years ago. This person had sent to him (the Chairman) during the war, as a token of friendship, a Persian manuscript, which seemed to be of very great value on account of its rarity. It was a work written by an officer of the famous ruler of Herat, Shah Rukh Sultan, and contained, amongst other matters, a geographical account of the province of Khorassan about the year 1418. The writer seemed to have been a minister of the country, and evidently knew every village and stream in the province. He (the Chairman) had made three extracts from the manuscript, which he considered to be of the utmost importance, as they recorded a physical phenomenon, namely, the desiccation of the Aral, which he believed had never up to the present time been brought to the notice of the geographers of Europe, although, as before stated, the great Humboldt had devoted no fewer than 200 pages of his standard work to the discussion of this subject. In describing the lakes of Asia the writer came in regular order to the Aral, which was called the Lake of Kharesm, and he said, "In all the ancient books the Lake of Kharesm is described as the receptacle of the waters of the Oxus, but at the present date, which is A. H. 820 (A. D. 1417), the lake no longer exists, the Jyhún (or Oxus) having made a way for itself to the Caspian, into which it disembogues at a spot called Karlawn, as will be described hereafter in its proper place." Again, in describing the rivers of Asia, he said, "It is recorded in all the ancient books that from this point the River Jyhún (or Oxus) flows on and disembogues into the sea of Kharesm; but at the present day this sea no longer exists, the river having made for itself a new channel, which conducts its waters into the Caspian. The point of embouchure is named indifferently Karlawn and Akricheh. From Kharesm to the point where the river falls into the Caspian the greater part of the country is desert."

So much for the Oxus. With regard to the Jaxartes, this writer explained another point which was of some importance; for, although the Oxus might have been diverted into the Caspian, still, if the other river entered the Aral, it would still remain a sea. But it was stated as follows: —"The river of Khojend in the lower part of its course, passing into the desert of Kharesm, joins the Jyhún (or Oxus), and thus ultimately reaches the Caspian." From which passage he (the Chairman) understood that at that time, A. D. 1417, the Jaxartes below Otrar branched off from its present bed to the left hand along a line now marked by reeds and lagoons (see Meyendorf's map), and joined the Oxus between Kungrad and Khiva, the two rivers from that point flowing on to the Caspian in one and the same bed. This statement was of the more importance as it came from a writer thoroughly acquainted with the country. In addition to this, there was the testimony of the great Emperor Baber, who of course knew the geography of his own country, and who said that the Jaxartes in his time did not enter the Aral, but was lost in the desert. His (the Chairman's) belief was that it sometimes reached the Oxus, and was sometimes evaporated in the desert.

Such is the history of the Oxus and Jaxartes up to about the year 1500. From that time a second change began to take place. The rivers were then found to be going back into the Aral. It might not be generally known that Mr. Anthony Jenkinson, the agent of some English merchants,

passed across Central Asia to Bokhara as early as 1550. He landed on the shore of the Caspian at Ming-kishlag, and came down the coast to a point where, as he heard, the Oxus had formerly disembogued into the sea; but he was told that the river had lately changed its course and gone back into the Sea of Aral. The ruler of the country, Abul-Ghazi Khan, who had left a most elaborate history of it, gave distinct details of this occurrence, and mentioned the very year in which the river began to return into the Aral. He related how the stream gradually dried up, and formed the sea as it at present exists. Evidence indeed could be given of the condition of the stream, almost year by year, from that time to the present; but it would be sufficient to state that every modern traveller who had passed through those regions had found the old bed of the River Oxus exactly where it was originally described. It was first brought to our notice by Mouravieff, a Russian agent, who passed from the Balkan bay to Khiva in 1819. Subsequently Arthur Conolly, who was afterwards murdered at Bokhara, attempted to cross from Astrachan to Khiva, and he also came upon the old bed; and lastly Mr. Vambéry, whom the Fellows might remember seeing at a meeting of the Society two years ago, in his famous journey across the Turkoman desert, traced the same broad river-bed, and found that it was perfectly well known as the ancient bed of the Oxus. Hence it seemed that there was sufficient evidence to show that in early times, say from the year 500 before the Christian era to the year 600 after the Christian era, both the rivers ran into the Caspian, the Aral being non-existent; that after that, up to the year 1300, they fell into the Aral; that for the next two hundred years—namely, from 1300 to 1500—they came back into the Caspian; and that then, at a fourth stage, they gradually flowed back into the Aral, and formed the sea as we now know it.

The changes thus noticed were very important in reference to what might be the future history of these rivers and these countries. It was quite certain that, as the Jaxartes was now in the possession of Russia, so the Oxus must also naturally and necessarily be, in the course of time. Now he would read what was stated by Russian writers as the probable result of that event. The Russians almost always called these rivers by the names of the Amu Daria and the Syr Daria, instead of the Oxus and the Jaxartes; but he would, in reading the extract, use the latter names as being better known:—

"The Oxus is, for many reasons, of great importance to Russia than even the Jaxartes. It disembogued at one period into the Caspian, and its bed to that sea still remains. Some are of opinion that the course of the river can be again directed to its ancient bed, while others consider it impossible to do so. It can, however, be positively asserted that the existing information on this point is very superficial and inaccurate, and the question will never be satisfactorily settled until a scientific expedition be sent by the Government to investigate it in all its bearings. The southeastern shores of the Sea of Aral are well adapted for uniting the Jaxartes with the Oxus, and encourage the hope that the united mass of water of two such great streams may force their way through the old bed to the Caspian. The importance of this connexion will readily be understood, when it is remembered that a water-route in continuation of the Volga will be thus created, which will extend for 3000 versts into the interior of Asia,

and that the extreme points of this uninterrupted water-way will be St. Petersburg and the northern slopes of the Hindoo Koosh."

This was a result which he (the Chairman) considered highly probable, and he believed that many present at the meeting would live to see a direct water-communication from the Baltic to the vicinity of the Indian Caucasus, which was considered the natural geographical boundary of India. They must remember that already there was a direct water-communication from the Neva, by means of canals, to Lake Ladoga, and thence to the upper course of the Volga, and down that river to the Caspian. Then, crossing the Caspian, vessels could reach the mouth of the bed of the Oxus. He looked upon that prospect without any apprehension or dismay, regarding it as the natural extension of civilization, and believing that it would be for the general advantage of mankind.

3. *Professor Kekulé.*—It is with much satisfaction that we see it announced that Professor Aug. Kekulé of Ghent has been offered the directorship of the magnificent laboratory now nearly completed at Bonn. No chemist of his years has done as much, either theoretically or practically, for the establishment of the present views in organic chemistry. The law of saturation, which, as Wanklyn says, is to chemistry what the law of gravitation is to astronomy, we owe to Kekulé. It is therefore a most just recognition of his ability and service to tender to him the directorship of the Bonn laboratory.

3. *American Association for the Advancement of Science.*—The next session of the American Association will be held at Burlington, Vermont, and commence on the 21st of August next. Prof. J. S. Newberry is President for the year, and Dr. Wolcott Gibbs, Vice President.

OBITUARY.

THEOPHILE JULES PELOUZE, died on Friday last, the 31st of May, at his country house at Bellevue, close to Sévres. Born the 13th of February, 1807, at Valognes (Département de la Manche), he inherited his love for science and arts from his father, Edmond Pelouze, a man of great practical talents, formerly employed in the manufactory of Gobelins, and afterwards director of the gasworks of the Manby and Wilson Company at Paris. Pelouze the elder is known as the author of a great number of treatises on various branches of applied chemistry—on glass-making, on brick-making, on colors and varnish-making, on washing and bleaching for housewives, etc. His treatise on the last-named subjects was published under the name of his wife. His chief work, 'On the Manufacture of Gas,' was revised by his son, and came out in a second edition as late as 1859.

Young Pelouze entered life as a pharmaceutical chemist; but he was only twenty years old when Gay-Lussac made him his assistant, and published some of his researches conjointly with him. Three years later, in 1830, he became professor of chemistry at Lille. Here he examined the juice of beetroot, and, in conjunction with Kuhlmann, published a paper on its fermentation. From 1831 until 1847 he took the place of Gay-Lussac as Professor of Chemistry at the École Polytechnique, and at about the same time (1831) he was elected to supply the place of Thénard as professor at the Collége de France. Shortly after these elections Pelouze managed to go to Giessen, and to publish joint researches with Liebig on the ether contained in wine, to which they gave the name of œnanthic

ether, but which was afterwards proved by Delffs to be identical with pelargonic ether. In 1833 Pelouze became Assayer, and in 1846 Controller (Vérificateur) of the Mint. He was elected a member of the Académie des Sciences in 1837. Of republican views, and much interested in politics, he became prominent through the revolution of 1848. The provisional government elected him to a place which until then belonged to the nobility or to the chief dignitaries of the state, that of President to the Board of the Mint (Président de la Commission des Monnaies). This position he held until his death. He became successively knight, officer, and commander of the Legion of Honor. His private laboratory for pupils in the Rue Dauphine closed when he opened a laboratory in the mint.

The number of papers published by Pelouze is very great. We can only mention here the most prominent of his researches. Among these none will be better remembered than the investigation recorded in his paper on the transformation of hydrocyanic acid into ammonia and formic acid. This paper was published in 1834, but the importance of his discovery became evident at a much later period, when hydrocyanic acid was first produced from carbon and nitrogen. Then it was that the transformation which Pelouze had effected by treating hydrocyanic with a strong solution of hydrochloric acid attained its remarkable position as the first instance of the synthesis of an organic body from its elements. At the time of the discovery its real importance could not be appreciated, but even then the relation of formic to hydrocyanic acid was of much interest. Next in importance to this memorable paper are several papers on the products of the dry distillation of lactic, malic, and tartaric acids. Pelouze discovered lactic anhydrid and lactid. Maleic and pyrotartaric as well as pyrogallic acid, if not actually discovered were, at least, chiefly studied by him. The salts of lactic acid were likewise examined by Pelouze, and described in several papers, one of which he published conjointly with Gay-Lussac.

A memoir on mustard oil was published by Dumas and Pelouze; another on asparamid (asparagine) and asparamic acid by Pelouze and Bourton, and a joint research on curarine was published by Pelouze and Claude Bernard. In mineral chemistry nitrosulphuric acid constitutes his chief discovery. In applied science numerous contributions, particularly on fulminates and the manufacture of percussion-caps, and above all on glass, were published by him at various intervals. Pelouze had an interest in large glass works at St. Gobin, and his last communication made to the Academy, some months ago, treated on the subject of this manufacture. A treatise on chemistry in five volumes by Pelouze and Fremy has seen three editions, the last of which was published in 1866. All these publications, if they do not place him among the very first French savants, will preserve his name permanently in the history of science. His great kindness of heart, and sincere and active interest for his pupils, will not easily be forgotten. There are and have been witnesses to these genial qualities in England. Professor Crace Calvert and the late Mr. Stoikowitch were assistants to Mr. Pelouze. During the last year important researches on aniline colors were carried on in his laboratory by MM. Girard, de Laire, and Chapoteaut.—*The Laboratory*, i, 182, June 8, 1867.

EZEKIEL HAYES.—Mr. Ezekiel Hayes, whose name has appeared on the title page of this Journal as its printer, died suddenly on the 12th of May last. In all relations in life Mr. Hayes was a man of strict christian integrity; and throughout his connection with this Journal, he labored earnestly for the interests of both authors and publishers.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Lippincott's Vapor Index, or Psychrometric Calculator.*—The Vapor Index is a mechanical contrivance by JAS. S. LIPPINCOTT, Haddonfield, N. J., for finding, by inspection, the relative humidity of the air, from the readings of the wet and dry bulb thermometers.

In a circular card, near its margin, are twenty equidistant openings, through which may be seen on a larger card over which it turns a series of numbers (from 0 to 100), representing *wet-bulb* readings. Radially inward from these openings are corresponding ones, arranged spirally, and numbered from 0 to 25. These numbers are *differences* of wet-bulb and dry-bulb readings. The *relative humidity* is read off through the opening whose number is this difference in a given case, when the card is so turned that the wet-bulb reading is seen in the corresponding marginal opening.

The instrument is simple, and many may prefer it to a table of double entry, for obtaining the same results; although in our view such a table, printed on a smaller card than this, would be equally convenient, and more durable. But knowing of no such table on a card, we can recommend the "Vapor Index" as more easy of use than the large tables, such as Guyot's, and as sufficiently accurate for ordinary purposes. The wide distribution of the Vapor Index would tend to increase much the interest in making hygrometric observations.

Mr. Lippincott is deserving of much credit for his efforts to extend an interest in Hygrometry, both by this invention, and by an interesting paper in the Report of the Commissioner of Agriculture for 1865, in which he discusses the relations of atmospheric humidity to various important phenomena in Meteorology and Agriculture.

2. *General Problems of Shades and Shadows, formed both by parallel and radial rays, and shown both in common and in isometrical projection, together with the theory of Shading;* by S. EDWARD WARREN, C.E., Prof. Descript. Geom., etc., Rensselaer Polytech. Inst., Troy, N. Y., author of "Elementary Plane Problems;" "Drafting Instruments," etc.; "Elementary Projection Drawing;" "Elementary Linear Perspective;" and "Descriptive Geometry." 140 pp. 8vo, with 15 plates. New York, 1867. (John Wiley & Son).—In our last volume we briefly noticed Professor Warren's excellent "Plane Problems in Elementary Geometry," a work bearing on the science of drawing. In the work before us, the author treats with fulness and perspicuity, the subject of shades and shadows. The treatises of Prof. Warren are all well adapted for instruction in the the Engineering and other Scientific Schools of the land.

3. *The American Naturalist*, Nos. 3 and 4. Salem, Mass.—This new and valuable magazine fully sustains the character predicted for it, and realized in its first number. Its leading articles are of a popular character and such as to be read with interest, and understood by all classes, while its scientific miscellany, and correspondence, reports of the meet-

ings of Scientific Societies, etc., make it indispensable to every naturalist. Its illustrations are of a character rarely equalled in similar works.

No. 3, contains, Some Errors Regarding the Habits of Our Birds, by T. M. Brewer, M.D.; the Food of the Sea Urchin, J. W. Dawson, LL.D.; the Royal Families of Plants, C. M. Tracy; the Moss Animals, or Fresh Water Polyzoa, A. Hyatt; the Tarantula Killers of Texas, G. Lincecum; the Birds of Spring, J. A. Allen; the American Silkworm, L. Trouvelot; the Land Snails of New England, E. S. Morse; Reviews, Natural History Miscellany, etc.

No. 4, contains, The Recent Bird Tracks of the Basin of Minas, C. F. Hartt; the Habits of the Gorilla, W. Winwood Reade; the Moss Animals or Fresh Water Polyzoa, concluded; the Land Snails of New England, continued; Parasitic Plants, G. D. Phippen; Oyster Culture, F. W. Fellowes; the Scorpion of Texas, G. Lincecum, M.D.; A note from the far North (Russian America), J. T. Rothcock; etc.

4. *Tables for Qualitative Chemical Analysis;* Professor HEINRICH WILL of Giessen, Germany. Seventh edition, translated by Charles F. Himes, Ph.D., Professor of Natural Science, Dickinson College, Carlisle, Pa. Philadelphia, Henry C. Baird, 1867.—Professor Will's analytical tables have, in the earlier editions, become familiar to American students through Faber's translation. They furnish, undoubtedly, the most compact classification of reactions yet published. Dr. Himes's translation being from the seventh German edition, is considerably improved. He proposes it as a suitable text book for laboratory instruction in those colleges who are assigning to Natural Science a more prominent place in their courses of study. The book is convenient in size (octavo), and is published in good style.

5. *The American Annual Cyclopedia and Register of Important Events of the year* 1866, embracing Political, Civil, Military and Social affairs, Public Documents, Biography, Statistics, Commerce, Finance, Literature, Science, Agriculture, and Mechanical Industry. Volume VI, 796 pp., large 8vo. New York, 1867. (D. Appleton & Co.)—Appleton's Annual Cyclopedia is a very important contribution toward the political, civil and geographical history of this and other countries, and also is full of valuable articles in the various other departments which it aims to have represented. The volume for 1866 has a portrait of the King of Prussia as its frontispiece, and beyond, others of Bismarck and Garibaldi.

6. *Eaton's Arithmetic and the Decimal System.*—Prof. H. A. NEWTON, who has been among the foremost in labors to secure the introduction of the decimal system into the United States, has prepared an admirable chapter on the subject, as an addition to a new edition of Eaton's Arithmetic. It occupies pages 337 to 348 of the arithmetic, and consists of tables, explanations, and examples, all of which are well adapted to introduce the subject to the student and make him practically familiar with it. In view of the recent act of Congress with regard to the decimal system, this department of arithmetic ought at once to make a part of all the text-books used in the schools of the country.

7. *Micro-chemistry of Poisons, including their physiological, pathological and legal relations:* adapted to the use of the medical jurist, physician, and general chemist; by THEO. G. WORMLEY, M.D., Professor of Chem-

istry and Toxicology in Starling Medical College, and of Natural Sciences in Capital University, Columbus, O. xxxi, and 668 pp., 8vo, with 13 steel plates. New York, 1867. (Ballière Brothers).—Dr. Wormley has taken up the subject of poisons after a method wholly his own and has prepared a work of the highest merit, and practical utility. This volume treats first of the effects of poisons and the causes modifying them, the sources of evidence in cases of poisoning, and the methods of chemical analysis; and then proceeds to the special consideration of individual poisons, first the inorganic and then the organic. The new feature in his treatment of the subject consists in the use of the microscope for the study of the crystallizations resulting from the action of various reagents on the several poisons. The facts given are all from his own minutely careful experiments, and the results are exhibited with great perfection and delicacy on a series of plates from steel containing seventy-eight illustrations. The engravings are from the pencil and graver of Mrs. Wormley, and the artist, although but a novice in the latter art, has evinced that in such work she has no superior. We know not which to admire most, the masterly manner in which Dr. Wormley has treated his subject, the science of poisons, or the extreme beauty of the plates which supplement the text. The real practical value of the work the writer has already tested in connection with a case of poison by strychnine which he has now on hand. The Messrs. Ballière have issued the work in elegant style well comporting with its scientific merits. G. F. B.

8. *Chemistry of the Farm and the Sea, with other familiar Chemical Essays;* by Jas. R. Nichols, M.D. Boston, A. Williams & Co., 1867, 123 pp.—This volume includes nine chapters on the chemistry of the farm, the sea, a bowl of milk, the dwelling, a kernel of corn, obscure sources of disease, local decomposition in lead aqueduct pipes, bread-making, and the sun. It is an interesting book and will serve a useful purpose in popularizing science, though it is marred somewhat by inflation of style and errors of treatment.

9. *Annual Report of the Trustees of the Museum of Comparative Zoology, together with the report of the Director,* 1866.—This, the eighth annual report, shows continued activity in increasing the already vast collections of the museum. The Director's Report contains a general statement of the present condition of the museum, and a somewhat detailed account of his Brazilian Expedition and its important results.

10. *The Art of Perfumery and the Methods of obtaining the Odors of Plants,* with Instructions for the manufacture of perfumes for the handkerchief, scented powders, odorous vinegars, dentifrices, pomatums, cosmetics, perfumed soap, etc., to which is added an Appendix on preparing artificial fruit-essences, etc.; by G. W. Septimus Piesse, Analytical Chemist. 2nd American from the 3d London Ed. 402 pp., 12mo. Philadelphia, 1867. (Lindsay and Blakiston.)

11. *The Art of Manufacturing Soap and Candles,* including the most recent discoveries, embracing all kinds of ordinary hard, soft, and toilet soaps, especially those made by the cold process, the modes of detecting frauds, and the making of tallow and composite candles; by Adolph Ott, Ph.D., Practical and Analytical Chemist. 194 pp., 12mo, with woodcuts. Philadelphia, 1867. (Lindsay & Blakiston.)

The two volumes whose title pages are here cited are popular and practical works on the subjects of which they treat. The first dips somewhat into the history and esthetics of the art, as well as its science.

12. *Notice of Volume IV of the Paleontology of New York;* by JAMES HALL. 24 pp., 18mo. Published March, 1867.—We have barely space to announce the appearance of this pamphlet, just now received. It contains a brief statement of some of the views and facts which are contained in the forthcoming *fourth* volume of the Paleontology of New York, with lists of the species described. The limits and characteristics of several genera of Brachiopoda are discussed, and some points are illustrated by figures.

13. *Ueber die Verschiedenheit in der Schädelbildung des Gorilla, Chimpansé, und Orang-Outang, vorzüglich nach Geschlecht und Alter, nebst einer Bemerkung über die Darwinsche Theorie;* von Dr. TH. L. BISCHOFF, Professor der Anatomie und Physiologie in München. Mit 22 lithographirten Tafeln. München.—This work will be valuable to those engaged in the study of the Quadrumana, and especially to those interested in the comparison of their anatomy with that of man. The plates are of folio size, and admirably executed.

The part of the work which possesses most general interest, is of course the appended note on the Darwinian Theory. Some of the points are as follows.—The assertion so confidently brought forward that the anthropoid apes are the direct ancestors of man, is entirely unsupported by evidence; moreover it is even contrary to the Darwinian theory rightly understood, for the extinction of the parent form is the direct consequence of the development of an improved form. The great problem of organic nature is twofold: 1. The origin of the simplest original forms; 2. The causes and the mode of their operation, by which more perfect forms were developed. A great defect of Darwin's theory is that he leaves the first question unanswered. Admitting that certain organisms must have been created, what right has he to say that other organisms may not have been created at intervals, even to the present time? Another defect of the Darwinian theory is, that no cause is assigned for the commencement of variation. To say that organisms have at once the power of transmitting peculiarities by inheritance, and of spontaneously originating variations, is a contradiction in terms. Darwin's treatment of the second half of the second question is more successful. Natural selection and the struggle for life must henceforth be fundamental principles in any theory of development. Since no general cause is assigned either for the origin of life or for the commencement of variation, all that can be considered as proved is that certain forms have been produced by variation from certain other forms. The facts warrant no general induction. We must be very cautious in accepting plausible theories without sufficient proof. The vagaries of the "naturphilosophie" furnish an instructive example. The psychical difference between man and brute is not merely quantitative, but qualitative. The distinctive peculiarity of man may be designated as *self-consciousness* (selbstbewusstsein), or the faculty of making one's self and one's mental condition a distinct subject of thought. On this faculty depend other important peculiarities of man, viz., the capability of indefinite progress, the idea of morality, the notion of a future state, and the power of language.

14. *L'Unita delle Forze Fisiche Saggio di Filosofia Naturale.* Del P. Angelo Secchi, D.C.D.G. 511 pp., 8vo. Roma, 1864.—The principal object of this work, as stated by the author, is to present to Italian readers an adequate representation and exposition, in their own language, of the modern doctrine of the unity or convertibility of natural forces, and of the principle of conservation of energy. The style is professedly adapted to the comprehension of the majority of readers, especially for those not deeply versed in science. But though, for this reason, divested of the appearance of abstruseness, and free from difficult mathematical investigations, it is not, in the proper sense of the word, a *popular* treatise. Important modern discoveries and theories are very fully cited, and everywhere the work bears evidence of extended research, and a wide acquaintance with the literature of modern science. Though there is little that is absobutely new in it, the book is valuable and interesting, being as it is an able exposition of principles which may almost be called the corner-stone of modern physics. There is probably no book in which the subject is more fully and satisfactorily treated than in this. The author appears to us to do but scant justice to Mayer, to whom the whole subject is so deeply indebted; for he does not even mention him in the preface, where are cited the names of those who have contributed most to this branch of science, and he makes subsequently but slight reference to his discoveries. A. W. W.

15. *Carte Hydrologique du Département de la Seine*, publié d'apres les ordres de M. Hausmann, Préfet de la Seine, et executée sur la carte topographique de l'Ingénieur des Ponts et Chaussées, par M. Delesse, 1862, 4 sheets.—This admirable map represents, as its title indicates, all the natural and artificial water-courses of Paris and its vicinity. The basis of the map is the topographical survey by Letellier and Potiquet, officers of the department of des Ponts et Chaussées. Its scale is 1:25,000. The curves of equal elevation are given at intervals of four meters. The map is tinted according to the geological formations. On a map of this character all the drainage by rivers, rivulets, sewers, gutters, etc., is accurately given. The execution of the work is excellent, and its practical importance is very great.

16. *Memorie dell' Observatorio dell Collegio Romano;* Nuova Serie, vol. II, dall' anno 1860 al 1863, Pubblicate dal P. Angelo Secchi, della Compagnier di Gesu, Direttore, etc. Roma, 1863. 4° (16 numbers), pp. 128.—This volume contains the astronomical observations made at the Collegio Romano during the period indicated in the title. The principal subjects are the Comets II 1861 and III 1862, the solar eclipse of July 18th, 1860, and spectral analysis of the light from the heavenly bodies. With these is given also a memoir upon the connection between meteorological varieties and those of terrestrial magnetism.

Diagrams are given representing the appearance of the two comets, of the solar eclipse, of the planets Jupiter, Mars and Saturn, and of about twenty spectra of the planets and fixed stars.

The relations of the second of these comets to the August meteors makes the numerous representations of its telescopic appearance of special interest.

17. *Quelques vües generales sur les Variations Séculaires du Magnétisme terrestre*, 1er Fascicule, par V. Raulin. 8vo, pp. 92. Extrait des Actes de la Société Linnéenne de Bordeaux; t. xxvi, 1867.—The author

gives a large number of observations showing the secular variations of the magnetic needle in all parts of the earth. He explains them by a hypothesis similar to that proposed in this Journal, xxxviii, 69, 1840, by the late Chancellor Lathrop. Mr. Raulin supposes that a body of greater density than the fluid portion of the earth, more or less irregular in form, and having the properties of a magnet, forms part of the earth's mass, but is not attached to the external crust. The line joining the poles of this magnetic mass is directed along the chord that joins the actual magnetic poles of the earth. This mass does not rotate exactly with the earth's crust, but falls behind it one revolution in about 600 years.

18. *Annales Météorologiques de l' Observatoire Royal de Bruxelles;* publiés, aux frais de l'état, par le directeur A. Quetelet, 4°, première Année, 1867, Nos. 1–5 (Jan.–May).—These annals give, in 8 quarto pages for each month, observations at Brussels of the barometer and thermometer for 15 stated hours each day, with maxima and minima, observations of August's psychrometer four times a day, of Osler's anemometer 12 times a day, of the direction of the wind, the state of the sky, and the declination of the needle four times a day, and of the electricity of the air, and the amount of rain daily.

19. *The Laboratory:* a weekly record of scientific research. London. (James Firth.)—We have now received the 13th issue of this active little journal and find that it increases in value with every number. Originated to provide a more efficient means of interchange in thought between men of science, especially chemists, it has brought to the task men of the first ability; and now we see it announced that Prof. Kekulé has consented to contribute regularly to its pages. We commend "The Laboratory" to the notice of men of science, confident that the papers published in each number are well worth the price of subscription.

20. *The Record of Zoological Literature for* 1865. Vol. II. 798 pp. 8vo. Edited by Dr. Albert C. L. G. Gunther. (London, John Van Voorst).—A book almost indispensable for every working Zoologist.

21. *Chambers's Encyclopedia.*—The American edition of this important Encyclopedia, issued by Lippincott & Co., Philadelphia, has reached Part 115, which nearly finishes the letter T.

Mining and Metallurgy of Gold and Silver; by J. Arthur Phillips, Mining Engineer, Graduate of the Imperial School of Mines of France, &c. 8vo. Preparing for publication. (E. & F. N. Spon, London; J. Wiley & Son, New York.)

Notes upon the Geology of some portions of Minnesota, from St. Paul to the western part of the State; by James Hall. 12 pp., 4to. From the Trans. Amer. Phil. Soc., vol. xiii, 1867.

On the Distribution of Temperature in the lower region of the Earth's atmosphere; by Henry Hennessy, F.R.S., Prof. Nat. Phil. in the Catholic Univ. of Ireland. 58 pp., 4to, with a folded plate. Dublin, 1867. From the Trans. Roy. Irish Acad., vol. xxiv.

Proceedings Acad. Nat. Sci. Philadelphia, No. 1, Jan., Feb., March, 1867.—p. 2, On a new genus of Homoptera; *H. Skinner.*—p. 11, On some points in the Mammalian skull; *H. Allen.*—p. 13, On Itacolumite; *C. M. Wetherill.*—p. 15, On colonies of plants observed near Philadelphia; *A. H. Smith.*—p. 24, The Cutting Ant of Texas; *G. Lincecum.*—p. 31, Notice of a fossil skull of a large Turtle from the Cretaceous of New Jersey, Euclastes platyops; *Cope.*

Proceedings Bost. Soc. Nat. Hist., Vol. XI.—p. 71, Analysis of Meteoric iron of Colorado; *C. T. Jackson.*—p. 75, Diatoms of a deposit near L. Winisquam, in Laconia, N. H.; *R. C. Greenleaf.*—Diatoms of the White Mts., the minuteness, etc.; *C. Stodder.*—Infusorial Earth from Peru; *C. Stodder.*—p. 79, Diatoms and other microscopic objects of the Gulf of Mexico; *R. C. Greenleaf.*